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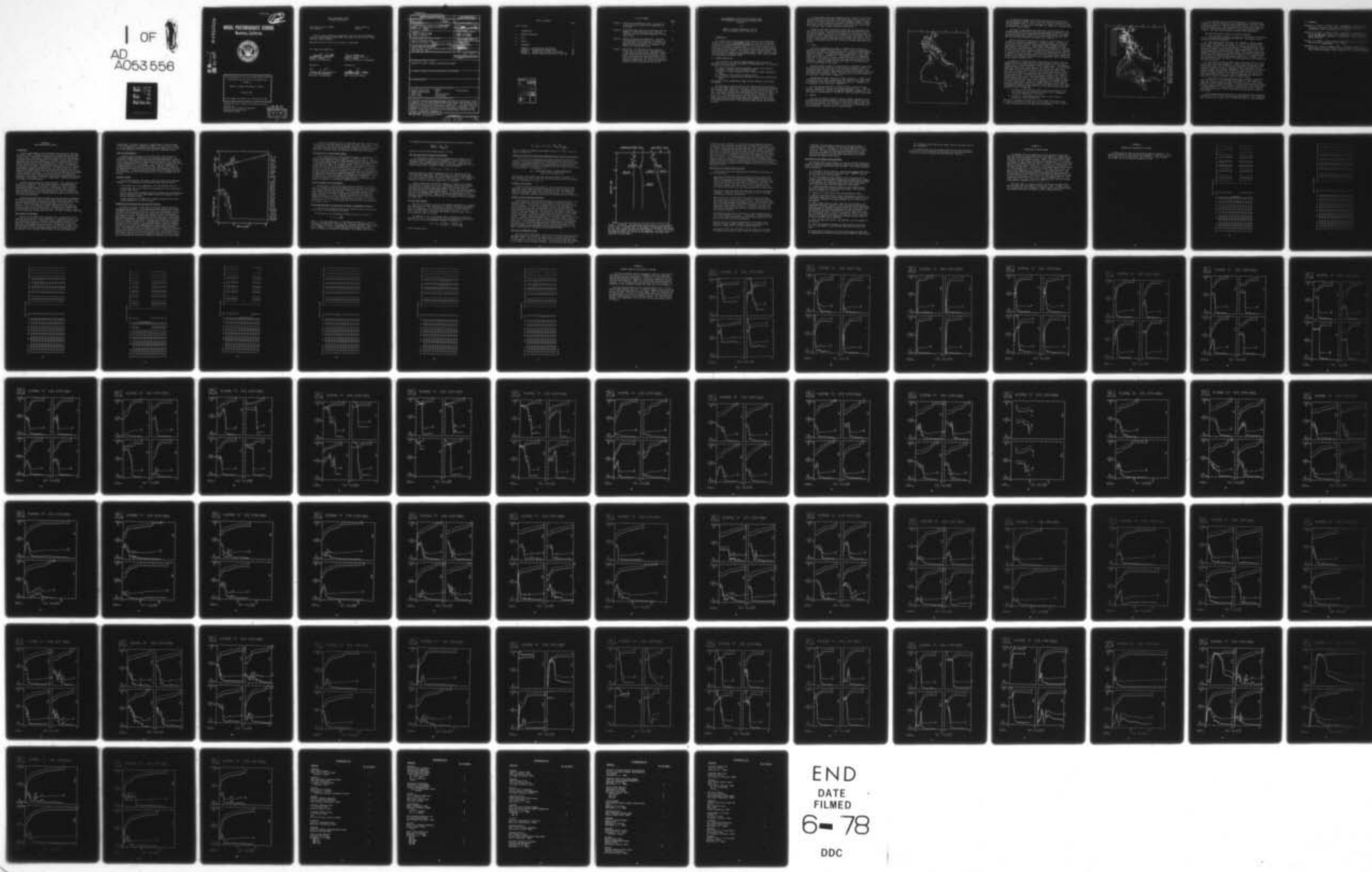

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The Oceanographic Cruise of the USCGC BURTON ISLAND to the Marginal Sea-Ice Zone of the Chukchi Sea -- MIZPAC 77

Robert G. Paquette and Robert H. Bourke

February 1978

Interim Report for Period July 1977-February 1978

Prepared for:
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Naval Oceans Systems Center
San Diego, CA 92152

NAVAL POSTGRADUATE SCHOOL
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This report presents the data and briefly describes the oceanographic results of the cruise of the USCGC BURTON ISLAND to the marginal sea-ice zone of the Chukchi Sea during the period 24 July to 6 August 1977. The distribution and intensity classification of temperature finestructure is described. Plots of temperature, salinity, density (σ_t), and sound speed are presented for each station. A detailed discussion of salinity spike removal and data editing routines is presented in Appendix A. included.

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THE OCEANOGRAPHIC CRUISE OF USCGC BURTON ISLAND TO THE MARGINAL SEA-ICE ZONE OF THE CHUKCHI SEA-MIZPAC 77

by

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I. INTRODUCTION

This report presents the data and briefly describes the oceanographic results of the cruise of USCGC BURTON ISLAND into the region of the sea-ice margin of the Chukchi Sea during the period 24 July to 6 August 1977 as part of the program designated MIZPAC 77. The primary objective of the cruise was to find and characterize finestructure in the vertical temperature profiles and to discover its horizontal distribution and causes. This is the fifth cruise devoted to this general problem. Other cruises in 1971, 1972, and 1974 were reported by Paquette and Bourke (1973, 1976) and MIZPAC 75 by Zuberbuhler and Roeder (1976).

II. GENERAL DESCRIPTION

The scientific group boarded BURTON ISLAND at Nome, Alaska on the afternoon of 24 July, one day later than in initial planning. The scientists and their affiliations were:

- Dr. Robert G. Paquette, Naval Postgraduate School, Chief Scientist
- Dr. Robert H. Bourke, Naval Postgraduate School
- LCDR Gordon P. Graham, Canadian Forces, Student at Naval Postgraduate School
- Mr. Jonathan D. Trent, Naval Postgraduate School
- Mr. Peter Becker, Applied Physics Laboratory, University of Washington, Seattle.

The scientific group disembarked at NARL, Barrow, Alaska on the afternoon of 6 August.

The measurements made were salinity and temperature profiles throughout the entire water column at 157 stations, using the Applied Physics Laboratory portable, hand lowered CTD. The lowering rate of the CTD was about 1 m sec^{-1} resulting in a data rate of approximately three points per meter. The latter was checked systematically with Nansen bottles lowered on a second wire. Prior to leaving each station, the temperature and salinity were plotted utilizing a Hewlett-Packard 9100 series computer/plotter system. These rough plots were used to make immediate assessments of the presence of finestructure and to aid in the decision of where to make the next few stations.

A current meter, which was intended to orient lines of closely spaced stations along the flow direction, was found to be of little utility because of the effects of the ship's iron on the magnetic compass. However, the failure to orient sampling lines along a presumed direction of propagation was at least partially overcome by running east-west lines as well as north-south lines in areas containing finestructure.

Because of the loss of one day of cruise time, no measurements were made in Bering Strait and the southern Chukchi Sea until the latitude of Pt. Hope was reached. Otherwise, we proceeded as in the general plan, exploring for finestructure along the ice margin from 70°N toward Barrow and studying it both in longitudinal and lateral sections when found. This resulted in much intensive study near Barrow followed, near the end of the cruise, by exploration near 71°N and, finally, a few more measurements near Barrow.

III. DATA

The CTD was standardized by means of a Nansen bottle lowered on a second wire to a depth just above the sea floor. Forty-nine such comparasons were in sufficiently unchanging water for temperature standardization and 40 for salinity. The mean CTD temperature and salinity errors were 0.08°C and -0.021°/₀₀, respectively. The standard errors of these means were 0.0051°C and 0.005°/₀₀ and the standard deviations were 0.036°C and 0.025°/₀₀. A correction was applied to the depth data to account for the difference in density between fresh and salt water, as the CTD pressure sensor was calibrated in fresh water.

The CTD records its data on a cassette which is eventually transferred to a seven-track tape by APL-UW for data editing and analysis at NPS. A computerized editing routine was written to remove erroneous data, interpolate data where necessary, make temperature, salinity and depth corrections, and remove spurious salinity spikes. The despiking and editing procedures are described in some detail in Appendix A.

Heading data for each station are listed in Appendix C. These contain station position and number, date/time of CTD lowering, water depth, type of navigation, wind, wave, and air temperature data, etc. Appendix B is an explanation of the codes used in Appendix C.

Plotting routines were used to display property profiles for each station: temperature, salinity, sound speed, and density (σ_t). These are compactly plotted four stations per page and displayed in Appendix D. Stations taken in the deep water of the Barrow Canyon are shown two per page.

IV. RESULTS

The array of stations occupied is shown in Figure 1 together with an ice-margin position based principally upon observations made at the times stations were occupied. The ice-margin is thus not a single synoptic view, but a progressively distorted one which is more useful in describing ice-related phenomena. Synoptic views are also available.

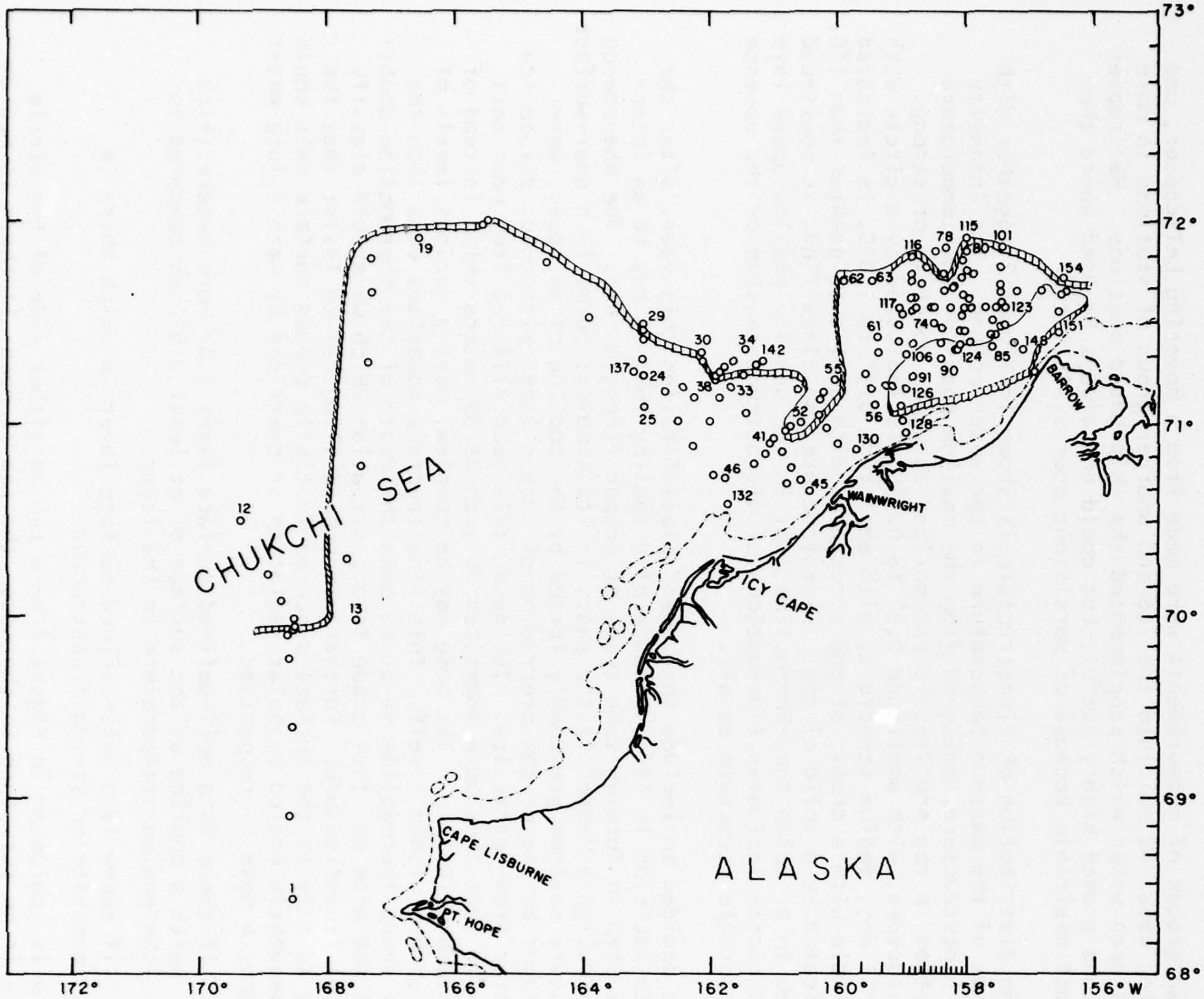

Figure 1. Station plot of MIZPAC 77 cruise. The position of the ice margin at the time of observation is also shown.

An interesting feature of the ice in the region of Pt. Barrow is the large embayment to the WNW. Most of the satellite-derived observations show the embayment more or less closed near Pt. Franklin but the ship found an open passage. A projection of ice toward Pt. Franklin is a feature which persisted for several weeks.

Two groups of measurements were made from a hovering helicopter, one extending about 40 nmi into the ice and another group of stations in more or less open water which supplemented the ship-based stations. Helicopter operations proved highly useful, but could not always be used where they were most desirable because of persistent poor visibility.

The distribution of finestructure is shown in Figure 2 together with isotherms of the maximum temperature in the water column. The intensity of the finestructure, measured from the maximum peak-to-peak temperature fluctuation in the profile, is categorized as weak, moderate or strong. Weak structure, with amplitude 0.2° to 0.5°C, is indicated by a circle with a central dot; medium structure, with amplitude 0.5° to 1.0°C, is indicated by a circle with a cross; strong structure, with amplitude greater than 1°C, is indicated by a solid circle. Finestructure, so classified, is construed as being in or below the thermocline, not in the usually shallow upper layer. An open circle indicates fluctuations of microstructure size or the absence of any notable structure at all.

We decided to include the "nose" classification this year, after the opposite decision in 1975, because of a feeling that it may be an intermediate step in forming some types of deeper finestructure. The phenomenon we have called a "nose" in the past, in its simplest form, is a near-surface temperature maximum presumably formed by the cooling of an upper, warm mixed layer by ice or the overriding of such a layer with cold, dilute ice-melt water from nearby ice. The noses this year differed from most past results in that they were sometimes as much as 30 meters thick instead of the customary 10-15 m. The nose may be complex, having various levels of finestructure within itself. This finestructure sometimes cuts into the usually sharp thermocline so as to make the depth of the thermocline doubtful and the nose can thus grade into a situation which we should classify as normal finestructure. Further, it seemed illogical to insist that the cooling be only at the surface since an initially cooled surface skin could be subsequently heated by solar radiation or overriden by warm dilute water. Therefore, a nose is recognized

a. if there is a well-defined surface layer 5 or more meters thick with a cooling at the surface of at least 0.5°C as compared to the maximum temperature in the layer.

b. if there is a well-defined surface layer in which there is moderate or strong finestructure.

The nose is indicated in Figure 2 by a tab on either side of the circle. If there is no structure in the nose, the tab is open; if there is medium or strong structure in the nose, the tab is filled solid.

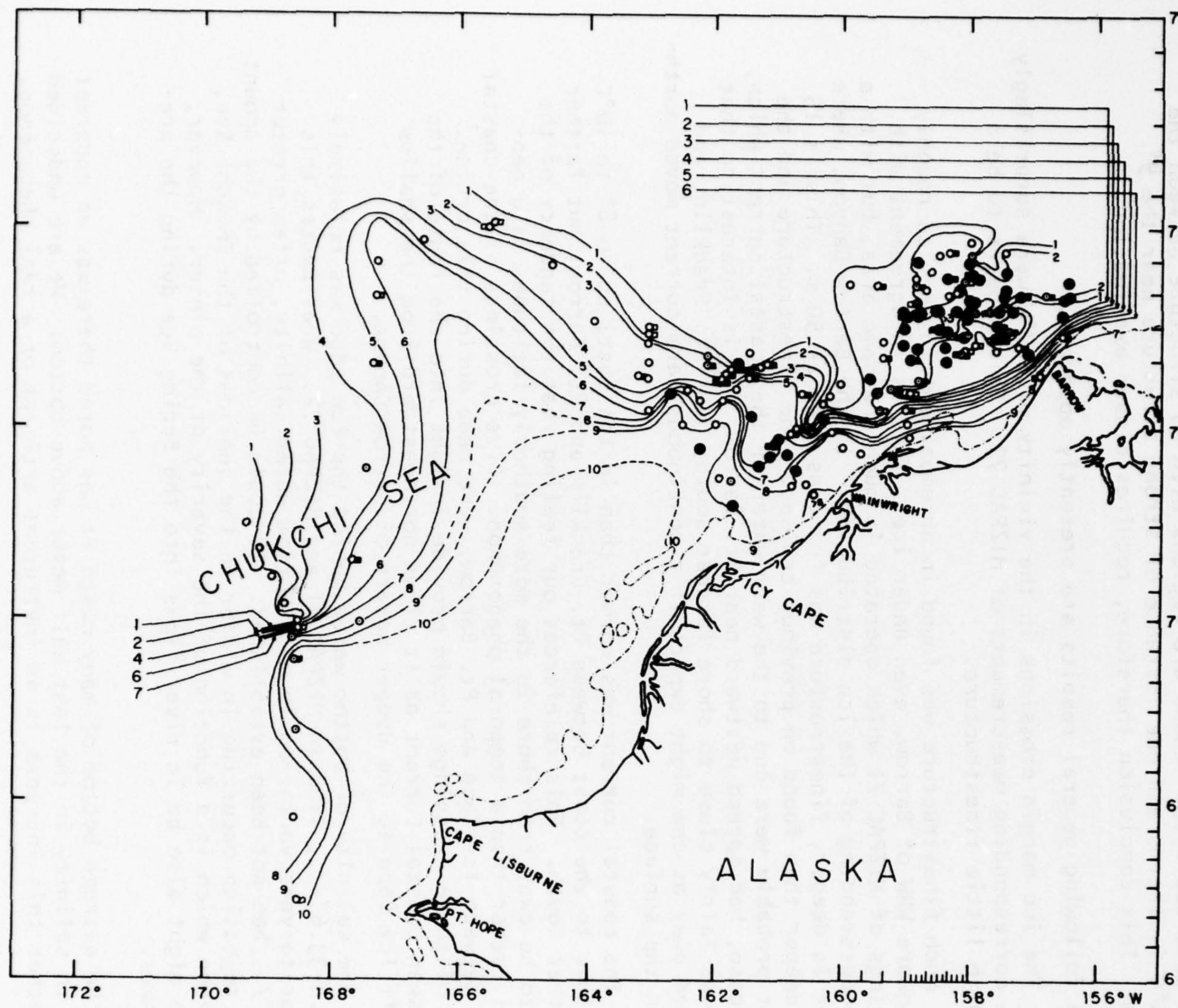

Figure 2. Distribution and intensity of finestructure during MIZPAC 77. Symbols are described in the text. Isotherms (°C) are the maximum temperature in the water column.

It will be noted that much of the finestructure is concentrated between the 2° and 4°C isotherms of maximum temperature in the water column, a conclusion reached in studying earlier data. However, this is far from being an absolute rule: there are regions with no structure between the 2° and 4°C isotherms and one instance of strong structure near the 9° isotherm. This conclusion therefore, requires closer examination.

The following general results are presently apparent.

1. The ice margin crossings in the vicinity of 167°W were surprisingly like the corresponding measurements of MIZPAC 72. This appears to be a region with little finestructure.

2. Much finestructure was found in an embayment in the ice roughly 40 nmi square WNW of Barrow, even under ice. This is in agreement with the findings of MIZPAC 71 which operated in much the same area, but with a poorer understanding of the ice distribution. In the Barrow Canyon, where the water is deeper, finestructure was found as deep as 50 m. This is 15 to 20 m deeper than found on previous cruises. The finestructure and the embayment probably were due to the warm water of the coastal current which, in this case, had spread westward near Pt. Barrow. It is interesting that the ice was fairly close to shore farther south, near Pt. Franklin, and not melted away as one might expect if a continuous warm current moved northward near the surface.

3. The coastal current was warmer than in the past, up to 8° to 10°C. It was close to the coast between Pt. Franklin and Pt. Barrow, but farther away farther south. This reinforces our feeling that the tendency of the current to be away from shore in the more southerly latitudes is a geographical rather than a temporal phenomenon. Five crossings of the coastal current, between Icy Cape and Pt. Barrow, were made during this cruise. Analysis of these crossings should provide insight into the route of the warm Alaskan Coastal Current as it flows northeastward from the shallow waters off Icy Cape to the deeper waters of Barrow Canyon.

4. The salinity of bottom water behind the ice edge was relatively high, 33.4-33.6°/₀₀, like in MIZPAC 71 and MIZPAC 72. What causes this large year-to-year variation in mean bottom water salinity, often greater than 0.5°/₀₀, has not been established. It could be controlled by the amount of brine rejection occurring in winter in the shallows of the Chukchi Sea, a phenomenon which is a function of the severity of the winter. However, the cause might also be in river flows into the Bering Sea during the previous summer.

At the extreme bottom of many casts it was noted there was an apparent increase in salinity in the last half meter above bottom. We are undecided about whether this increase is an instrument artifact or a real phenomenon.

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APPENDIX A
DESPIKING AND DATA EDITING

Introduction

Salinity spikes appear to be considerably more serious in 1977 than they were in 1975. This must be due to the instrument modifications made in the interim. Some objective despiking routine obviously was required. In October 1974 we had tested a despiking program for an old model Plessey STD based entirely on the concept of a first-order response equation for temperature and some phase shift between salinity and temperature, which Scarlet reported using, without the phase shift, in 1975. The method did not work well on our data. Constants which would correct the top half of a spike would overcorrect the bottom half. The reasons may lie in second-order effects, perhaps complicated by the fact that we worked from the graphically recorded output rather than from digital data and thus included recorder response in the data. Or it may be that the technique which Scarlet found suitable for small spikes could not handle the very large spikes occurring in the Chukchi Sea data which were further exaggerated by the long thermometer time constant of the STD. Nevertheless, necessity prompted us to try again, with some success.

The data editing program to be described also is not completely new. We had one in MIZPAC 75. But the present program is considerably more versatile and automatic. It contains a "ratchet" or "latch" subroutine which prevents depth reversals similar to the one described by Scarlet. Our routine differs in that Scarlet threw out offending data whereas we replace offending points with interpolated points. This is necessary because we do not record time on the tape and must assume that the time step is uniform when despiking.

Despiking experiments have proceeded at the Applied Physics Laboratory, University of Washington (APL) and at the Naval Postgraduate School (NPS) with considerable general communication between the two laboratories. The method of handling the short time constant below is due mainly to G. Garrison of APL, the method of correcting temperature and the long time constant is due to R. G. Paquette of NPS. The details of implementation by APL and NPS are different and we have not intercompared results. The editing program described was evolved at NPS. APL uses a different technique.

Facts about the Instrument

The CTD is a portable digital instrument with a conventional three-electrode conductivity cell and a thermistor as a temperature sensor. The cell constant of the cell is remarkably stable, judged by classical ideas about polarization phenomena in cells with unplatinized electrodes and relatively high electrode current densities. Perhaps this is due to the high operation frequency, ca 10 kHz, and the low electrode voltage, 13 mV. The three sensors of the instrument produce electrical frequencies which are counted in the instrument and the counts are recorded digitally on

cassette tape. The sensor data set is sampled about 3 times per second in the order conductivity, temperature, depth. The fact that the conductivity and temperature measurements are separated by about 30 ms is a factor in the generation of salinity spikes and their subsequent removal.

Salinity Spikes-General

Spurious salinity spikes in a CTD record result from the lack of simultaneity between the conductivity and temperature measurement. The spikes are of consequence only when there are sharp temperature transients. A time lag may occur because of sampling lag, as above, or it may occur because of response lags in the sensors. The effect exists whether the salinity is computed digitally or by an analog circuit. When the temperature is retarded compared to the conductivity by either mechanism, the spike has the opposite sense from the first derivative of the temperature-time curve and conversely. If both measurements are effectively simultaneous but both are wrong because of sensor lag, the salinity, if slowly changing, may be correct.

Sources of spikes

In our investigation of the cause of salinity spikes, which sometimes exceeded 1°/₀₀ in magnitude, we found several sensor response errors.

- A first-order lag in the temperature, with time constant 0.05 sec.
- A first-order lag in the flushing of the conductivity cell with length constant about 18 cm.
- An error due to non-simultaneous sampling of conductivity and temperature and to a physical vertical displacement between the conductivity cell and the temperature sensor.
- A long time constant in conductivity response apparently due to heat storage somewhere in the cell structure.

Recognition and Evaluation of the Long Time Constant

It may be of interest to know how the long time constant came to be recognized and evaluated. It was found only because data were recorded on the upward traverse of the CTD as well as when it was going down. It was then noted that the down-going salinity curve often did not agree with the up-going curve in the region below the thermocline where the temperature was unusually constant. No temperature-induced salinity error should have been generated *in situ*. Obviously the error must have been a long-lasting effect of a salinity or temperature transient which occurred at a shallower level and affected the down trace. The upward-going trace must have been essentially correct (except for the neglected effect of salinity change on conductivity) so long as the temperature was constant because the sensors usually were held near bottom for perhaps 10 seconds before beginning to hoist. The phenomenon under discussion may be seen in Figure 3, which shows the down and up salinity traces in Station 80 as well as the down and up temperature traces and the corrected salinity trace. One may easily find a time constant of about 5 sec in the approach of the salinity down trace to the up trace below the thermocline, taking the lowering rate to be 1 m/sec.

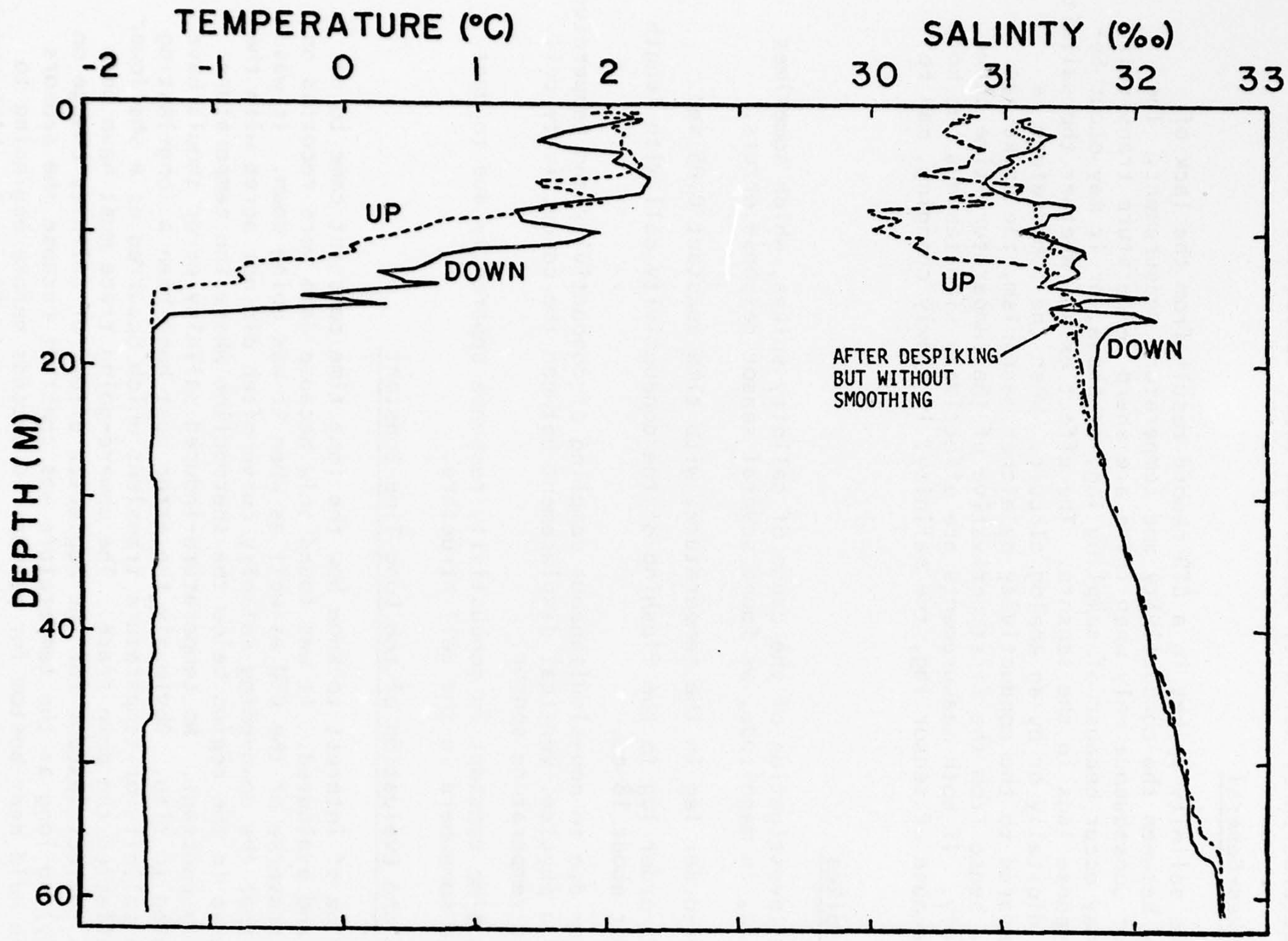

Figure 3. Station 80 salinity and temperature. The solid line was obtained while lowering, the dashed line while hoisting. The dotted line is the result of despiking the down trace but not smoothing. See Figure 4 for the smoothed curve.

If such a time constant exists in other STD's and CTD's, there must be difficulties in removing spikes by the use of a single time constant. This is because the short and long time constants contribute differently to narrow spikes than to broad spikes; the short time constant influences the former more than it does the latter and conversely for the long time constant.

The Possibility of Second-Order Effects

All of the discussion of spike correction below will assume the simple first-order response equation for sensors. It should be kept in mind, however, that substantial second-order components may be present. Whenever there are two thermal masses in series with two thermal resistances involved in the transfer of heat from the water to the interior of the sensor, a second-order term enters the response equation. The temperature and salinity sensors must have had these characteristics to some extent, but it was not possible to find the multiplier of the second-order term. A second-order corrector basically takes out curvatures. It was found that the second-order constant could be adjusted to take out anomalies in the curves beautifully, but there was no way to tell whether the corrections corresponded to reality. Therefore, after a few experiments, the refinement was abandoned. It may be possible to revive it at some later date when more is known about the causes of variability of the sensor response constants.

Lack of Constancy of the "Constants"

A major problem in devising a spike correction technique is the fact that the response constants of the sensors are not constant. They change with rate of lowering, wire angle and relative horizontal motion between the sensor head and the surrounding water. If the constants had been nicely fixed, there would have been straightforward techniques for evaluating several constants. As it was, there was little hope of evaluating the second-order constant and little justification for trying to compute the effect of the flushing constant of the cell upon the conductivity directly, a matter which will be discussed below when the methods of spike correction are related in detail.

Theory and Algorithms for Correction of Spikes - Thermometer Correction

In the following paragraphs the nature, causes and method of correction of the several time constants are discussed.

We assumed that the thermometer followed a simple first-order law

$$T - T' = k_T \frac{dT'}{dt}$$

where T is the water temperature, T' the observed temperature, k_T the time constant of the thermistor and t the time. The bare thermistor had a nominal time constant of 0.03 sec. The protective shroud was expected to add to this. After a number of trials we picked 0.05 sec as the largest value which would not produce an overshoot at the bottom of the sharpest thermoclines.

The temperature derivative was obtained from the first central difference

$$\left(\frac{dT'}{dt}\right)_j = \frac{T'_{j+1} - T'_{j-1}}{2h}$$

where $\underline{h}$ is the time step between samples, 0.33 sec.

The Time Lags and the Flushing Time Constant

The difference in sampling times of temperature and conductivity was 0.03 sec (temperature latest) plus an addendum of 0.01 sec because the thermometer was 1 cm deeper than the mouth of the cell. These were compensated by interpolating backward toward the previous temperature a fractional distance (0.01 + 0.03)/h or 0.012, using the equation

$$\Delta T_j = k_c T_{j-1} + (1-k_c) T_j - T'_j$$

where the constant k_c would be expected to be 0.12, from above, but was more effectively about 0.65. The extra 0.53 can be shown to approximate a correction for the flushing lag in the conductivity cell, which apparently has a time constant of 0.53 h or 0.18 sec. This corresponds to a length constant of 18 cm, or one cell length, which is reasonable.

There are some known theoretical weaknesses in treating the flushing time constant of the cell in this way. The method involves the assumption that there are no significantly large conductivity gradients that are not caused exclusively by temperature changes, which is the same as assuming that the true salinity always changes slowly. It also involves the assumption that the first backward temperature difference is proportional to $\partial c/\partial t$, where $\underline{c}$ is the conductivity. These are not always good assumptions. However, reasonable success with the techniques led us to postpone further refinements to a later date.

The Long Time Constant

The long time constant in the cell was modeled successfully as a thermal mass coupled to true water temperature by a thermal resistance corresponding to a time constant k_L. This mass passes fraction $\underline{F}$ of the difference between its temperature and true water temperature to the cell. It is a fairly realistic model. The thermal mass might be the cell body itself or the surrounding protective shroud.

The temperature, TC, of the thermal mass is accumulated at each step, starting with $TC_1 = T_1$ and assuming that the mean temperature difference between TC and T drives the temperature change in accordance with

$$TC_j = TC_{j-1} + \left[\frac{T_j+T_{j-1}}{2} - \frac{TC_j+TC_{j-1}}{2}\right]\frac{h}{K_L},$$

which ultimately gives

$$TC_j = \left[T_{j-1} + T_j + TC_{j-1} \frac{(2k_L - h)}{h}\right] \frac{h}{2K_L+h} .$$

Then the temperature addendum contributed to the cell is $\Delta TC_j = (TC_j - T_j)F$, where F is about 0.15.

Difference Equation for Converting Temperature Error to Salinity Correction

At this point in the discussion, all the corrections have been computed in terms of their equivalent temperature corrections assuming C_j may be taken as the observed conductivity. The effects of k_c and k_L on salinity were then computed separately by a difference equation derived from the salinity temperature - conductivity tables of H.O. Pub. SP-68 in the vicinity of 2°C and 30°/₀₀. This equation is

$$S-S' = \frac{-11.0 \times 10^{-5} (T-T') - 2.28 \times 10^{-5} S'(T-T')}{76.8 \times 10^{-5} + 2.28 \times 10^{-5} T}$$

When the short time constant and the time lag were being corrected, T-T' was replaced by ΔT_j above. When the long time constant was being corrected, T-T' was replaced by $T_j + \Delta TC_j - T'_j$.

Example of Corrections

Figure 4 shows the original salinity curve from Station 80, the two components of the despiking correction and the resultant corrected curve. There were nearly always some small irregularities left after despiking. These were smoothed by means of a 9-point running mean. The corrected salinity curve before smoothing may be seen as the dotted curve in Figure 3.

Method of Finding Despiking Constants

The constants for despiking were determined in the following way. The despiking program was used intensively on about ten different stations, including some of the up traces, to become familiar with the effects of the several constants. In this way the general range of the constants and their variability was found. The constants k_L and F were determined as those which would make the down trace and the up trace match, or be nearly parallel below the thermocline. The constant k_c was chosen to remove spikes as well as possible. Sometimes it was necessary to adjust F also to remove spikes which meant that perfect matching of up and down traces was not possible. However, perfect matching is not a requirement unless the salinity curve is nearly vertical near bottom because a salinity gradient causes a small error in cell response which is not corrected by k_c, as was explained previously. The despiking program was then incorporated into the general editing program. During the general editing, further adjustments of the despiking constants were made before writing the corrected values on a new tape. A description of the general editing program follows.

Some Tests of Responses at Sea

Two stations were duplicated. In the first run of Station 46, the lowering was made by backing up 1/2 meter for each meter of lowering through half of the water column. The rest of the drop was made at normal speed, ca 1m/sec. In the second run the lowering was normal. It was expected that the response of the sensors would be notably different. The spiking was less serious

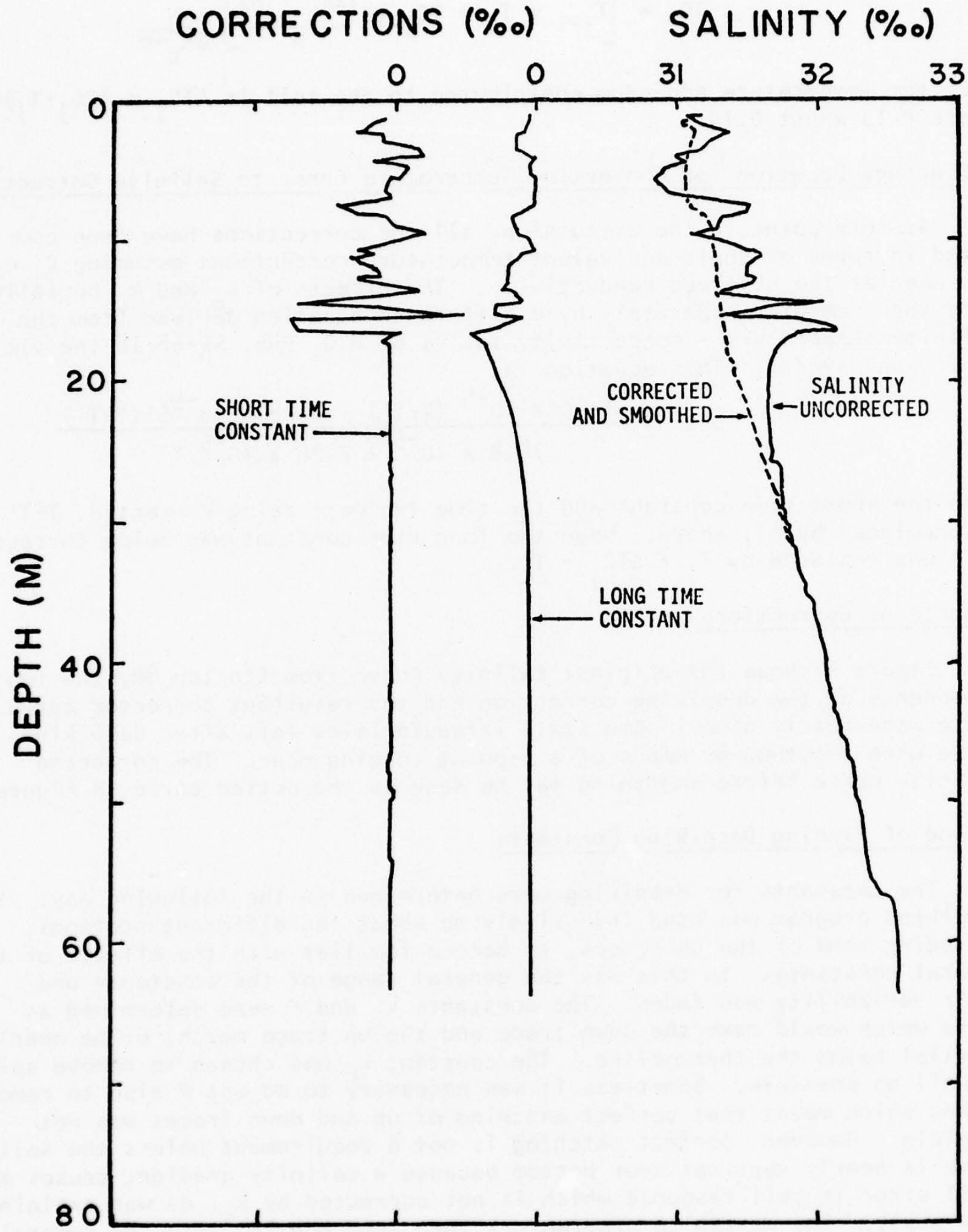

Figure 4. Station 80. The down-going salinity profile is on the right as a solid curve. The dashed curve is the result of despiking and smoothing. The two curves to the left give the contributions of the short time constant and long time constant corrections to the despiking. See Figure 3 for the unsmoothed corrected curve and to see the temperature transients which caused the salinity spikes.

in the first case. However, it is curious that the despiking constants required for the first were the normal ones, $k_c=0.65$, F=0.15 whereas, for the second, $k_c=0.38$ and $k_L=0.115$ were required. The corrected results are very similar except near the surface where rapid real changes in properties are common. In Station 107, the first drop is normal and the second was made with the thermistor taped onto the multiplexer housing facing upward. The smaller spikes of temperature and salinity were smoothed in the second case, presumably by the turbulence generated by the multiplexer housing. This is a station in which the temperature transients are moderate and, although there were differences in the original curves, they are not dramatic enough to interpret in terms of the different cell-to-thermistor distance. Both lowerings were corrected with the standard constants and, when corrected, looked very similar.

Requirements for General Editing of Data

The CTD data require considerable editing besides the despiking, as will be noted below.

- Spurious high salinities frequently occur near the surface on the down trace, and the first one or more depths are occasionally very large. High apparent salinities are created by very low actual conductivities due either to melt water or to bubbles in the cell. The system records only four digits of a five-digit frequency count. Therefore, foldover occurs as a result of low values and the last four digits are at the top of the range and are read as high values.

- Occasionally an absurd single value may occur in any of the measured parameters. Sometimes the error is too small to be distinguished automatically from real fluctuations.

- Near the top of a lowering there are duplicate values generated during the "soaking" period and also while the sensors are waiting near bottom while buttons are pressed on deck. The shallowest depth may be interspersed among other depths near surface; a similar result occurs near bottom because, after striking bottom, the sensor was immediately raised one or two meters. A method is required to remove the unwanted records and to start as shallow as possible and end as deep as possible.

- Some lowerings were so full of noise as to require replacing them with the corresponding up trace. In such cases, special adaptations of the noise-removal and despiking routines were necessary and the data set was then inverted top-to-bottom.

- When the ship rolls, loops are generated in the recorded traces because of sensor response problems. Records distorted by such reversals in depth had to be adjusted before despiking.

- The several sensors have calibration errors, additive in the case of temperature and salinity, and a factor for converting from the

fresh-water to a salt-water calibration in the case of depth. A substantial depth discrepancy will be noted between down and up curves in Figure 3. The cause is only partly known and it was not corrected. The major contributions are a sampling lag of twice 255 ms and the probability that temperature features in the water were carried upward by the multiplexer housing of the CTD which preceded the sensors on the way up.

Description of the General Editing Program

The complete data editing program is a group of routines which may be invoked in sequence by commands entered on a control card read immediately before the data to be edited were read from tape. The following functions could be performed.

1) Eliminate an entire "station". Here the word station means those data isolated on the tape by interrecord gaps. Usually it was the up trace which was to be eliminated.

2) Eliminate sequential data records in up to two places on any station, the places designated by beginning and ending serial numbers of the records. This served to remove faulty values frequently found at the beginning of a lowering and the repetitious values usually found where the sensor head was stopped on or near bottom.

3) Interpolate between two good records as many records as were previously present in a faulty intervening group. This could be done in two places on any station.

4) Replace up to three records with images punched on cards.

5) Remove single-point spikes in depth, temperature or salinity. A single-point spike found in one of these was almost certainly an artifact and was replaced by the median between the J-1-th and J+1-th measurement.

6) Apply a depth ratchet so that, after the first 20 points, the depth cannot decrease. Records in which the depth has decreased as compared to D_i are replaced by an equal number of records interpolated evenly between D_i and the next depth which is equal or greater. At the beginning, the routine automatically discards records prior to the minimum depth found in the first 20 records. Where this routine was to be applied to an up trace, a variable, UP, was set true which caused all the depths to be temporarily replaced by their negatives so that the ratchet routine would work.

7) Apply the despiking routine. The constants could be changed for each station.

8) Invert the sequence of records, putting the top at the bottom, this for a few cases in which the down trace was too faulty to be used.

9) Make additive corrections to salinity and temperature based upon the comparisons with Nansen bottles and correct depth for water density.

10) Recompute sound velocity and sigma-t from the corrected salinity and temperature.

The program then wrote the corrected data on a new tape, produced a printer plot of the corrected and uncorrected salinities and the contributions of the long-time constant and lag corrections separately.

APPENDIX B

EXPLANATION OF HEADING CODES

The heading of the printed output uses the coding and format from NODC Publication M-2, August 1964, with a few exceptions. Heading entries which are not self-explanatory are as follows: MSQ is the Marsden Square, and DPTH is the water depth in meters. Wave source direction is in tens of degrees, but the direction 99 indicates no observation. The significant wave height is coded by Table 10 (Code $\div$ 2 $\simeq$ height in meters) and the wave period is coded by Table 11 (Code $\div$ 2 $\simeq$ period in sec); in each case X indicates no observation. Wind speed, V, is coded as Beaufort force, Table 17. The barometer is in millibars, less 1000 if more than 3 digits; wet and dry bulb temperature are in degrees C. The present weather is from Table 21 with cloud type and amount from Tables 25 and 26, respectively. The combination 4 X 9 indicates that clouds cannot be observed usually because of fog conditions. The visibility is from Table 27 which is roughly in powers of two with Code 4 = 1-2 km. The ice concentration, IC, is in oktas; amounts less than 1 okta are preceded by a minus sign and indicate concentrations in powers of ten, e.g., $10^{-4} = -4$.

The entry, COD, is a code to identify the accuracy of each station position based upon the navigation system used. Code 1 indicates a position determined by visual sightings or radar, Code 2 a position determined by navigation satellite, and Code 3 a position determined by DR.

APPENDIX C

HEADING DATA FOR MIZPAC 77 STATIONS

Heading data are listed on the following pages for MIZPAC 77. The coding conventions are those described in Appendix B. Note that Stations 67H through 71H and 97 are missing. Other stations in the helicopter series have much of the heading information missing.

MIZPAC 77 CTD STATIONS

NAT	SHIP	LAT	LONG	MSQ	MO	DY	YR	HR	STA	DPTH	COD	IC	WVD	HT	PER	WND	V	BAR	DRY	WET	WTHR	CL	AMT	VIS
31	BI	68-25.0	168-36.0	233	07	26	77	10.0	001	55	1	0	15	0		06	4	110	9.8	9.3	1	7	2	7
31	BI	68-53.5	168-28.1	233	07	26	77	13.4	002	51	1	0	06	0		06	4	106	10.7	9.8	1	3	4	7
31	BI	69-23.0	168-30.0	233	07	26	77	17.0	003	44	2	0	06	0		07	3	106	10.1	9.1	1	3	1	7
31	BI	69-47.0	168-30.0	233	07	26	77	19.7	004	49	2	0	06	2		10	4	110	9.9	9.1	0		0	7
31	BI	69-54.0	168-30.0	233	07	26	77	21.3	005	44	2	0	10	2		10	4	111	9.9	9.1	0		0	7
31	BI	69-55.5	168-28.2	233	07	26	77	22.3	006	44	2	0	10	2		10	4	112	9.8	8.9	0		0	7
31	BI	69-57.4	168-28.1	233	07	27	77	02.9	007	45	3	6	06	2		10	3	104	5.0	4.3	0		0	8
31	BI	69-59.3	168-30.0	233	07	27	77	04.5	008	42	2	6	00	0		08	3	102	4.1	3.8	1	0	2	6
31	BI	70-03.0	168-43.0	269	07	27	77	01.5	009H		2													
31	BI	70-12.0	168-54.0	269	07	27	77	01.3	010H		2													
31	BI	70-20.0	169-05.0	269	07	27	77	01.0	011H		2													
31	BI	70-27.0	169-17.0	269	07	27	77	00.9	012H		2													
31	BI	69-59.0	167-29.7	233	07	27	77	07.6	013	49	3	0	08	2		08	5	100	9.0	8.2	1	4	1	7
31	BI	70-19.7	167-38.3	269	07	27	77	09.7	014	49	2	0	05	2		07	4	101	7.0	6.8	1	4	2	7
31	BI	70-47.5	167-25.5	269	07	27	77	13.7	015	53	2	0	08	4		08	5	105	4.8	4.6	4	X	9	3
31	BI	71-19.5	167-18.0	269	07	27	77	17.1	016	48	2	0	08	4		08	4	115	3.7	3.5	4	X	9	2
31	BI	71-38.0	167-18.0	269	07	27	77	20.4	017	49	3	0	09	3		08	5	115	4.0	3.7	1	7	1	3
31	BI	72-00.0	167-18.0	269	07	27	77	22.3	018	48	3	0	09	2		09	5	115	3.8	3.2	1	0	4	7
31	BI	71-56.0	166-30.0	269	07	28	77	01.1	019	46	3	0	00	0		09	3	111	4.6	3.3	1	0	5	7
31	BI	72-00.0	165-30.0	269	07	28	77	03.0	020	43	3	2	00	0		09	4	110	1.5	1.1	1	0	3	7

MIZPAC 77 CTD STATIONS

NAT	SHIP	LAT	LONG	MSQ	MO	DY	YR	HR	STA	DPTH	COD	IC	WVD	HT	PER	WND	V	BAR	DRY	WET	WTHR	CL	AMT	VIS
31	81	72-01.0	165-25.0	269	07	28	77	04.2	021	57	3	5	00	0		11	4	110	.9	.7	1	0	5	6
31	81	71-48.9	164-30.0	269	07	28	77	07.2	022	38	3	0	10	0		10	4	109	1.8	1.3	1	7	6	7
31	81	71-32.1	163-50.9	269	07	28	77	09.3	023	55	3	0	10	0		10	3	108	3.1	2.8	1	7	6	7
31	81	71-14.6	163-00.0	269	07	28	77	12.0	024	53	3	0	08	0		08	4	098	4.3	3.7	2	5	8	7
31	81	71-05.2	163-00.0	269	07	28	77	13.1	025	44	3	0	00	0		12	4	099	6.0	6.4	5	5	8	6
31	81	71-19.8	163-00.0	269	07	28	77	14.7	026	51	3	0	00	0		10	3	101	4.0	3.7	5	5	8	7
31	81	71-25.6	163-00.0	269	07	28	77	15.7	027	45	3	0	09	0		09	3	102	3.1	3.0	5	5	8	7
31	81	71-28.5	163-00.0	269	07	28	77	16.6	028	43	3	1	00	0		09	4	102	1.5	1.5	5	5	8	7
31	81	71-30.5	163-00.0	269	07	28	77	17.5	029	41	3	5	00	0		13	4	106	1.5	1.5	5	5	8	7
31	81	71-22.0	162-05.0	269	07	28	77	21.1	030	48	3	-1	00	0		16	4	115	5.0	5.0	4	X	9	1
31	81	71-19.0	162-04.0	269	07	28	77	22.4	031	41	3	1	00	0		19	3	114	5.1	4.6	4	X	9	1
31	81	71-16.0	161-47.1	269	07	28	77	23.4	032	48	1	-4	00	0		22	3	127	8.6	[illegible]	4	X	[illegible]	4
31	81	[illegible]	[illegible]	269	07	29	77	00.5	033	44	1	0	00	0		19	2	132	10.0	[illegible]	4	X	[illegible]	[illegible]
31	81	[illegible]	[illegible]	269	07	29	77	[illegible]	034	41	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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MIZPAC 77 CTD STATIONS

NAT	SHIP	LAT	LONG	MSQ	MO	DY	YR	HR	STA	DPTH	COD	IC	WVD	HT	PER	WND	V	BAR	DRY	WET	WTHR	CL	AMT	VIS
31	BI	70-54.3	161-01.0	269	07	29	77	13.3	041	44	3	-4	00	0		09	5	144	4.9	4.9	5	X	9	4
31	BI	70-51.5	160-50.0	269	07	29	77	14.6	042	49	1	0	00	0		09	3	141	6.0	5.8	4	3	1	6
31	BI	70-46.5	160-41.5	269	07	29	77	15.3	043	48	1	0	00	0		11	3	140	10.8	10.2	4	3	6	6
31	BI	70-42.5	160-32.5	269	07	29	77	16.6	044	43	1	0	00	0		13	3	139	10.3	9.8	4	3	7	6
31	BI	70-39.0	160-24.0	269	07	29	77	17.6	045	23	1	0	00	0		11	3	142	11.4	10.7	4	3	7	3
31	BI	70-43.5	161-43.0	269	07	29	77	21.5	046	42	1	0	00	0		24	1	147	12.5	11.2	4	3	6	1
31	BI	70-48.0	161-17.0	269	07	29	77	23.0	047	47	1	0	00	0		06	1	152	11.8	10.8	4	3	6	6
31	BI	70-51.2	161-06.0	269	07	30	77	00.4	048	47	1	0	00	0		30	1	153	10.6	9.5	4	3	6	5
31	BI	70-56.0	160-58.0	269	07	30	77	01.3	049	50	3	-4	00	0		03	2	154	8.1	7.1	4	4	3	6
31	BI	70-59.5	160-41.5	269	07	30	77	02.5	050	47	3	1	00	0		05	2	154	7.5	6.1	4	4	2	6
31	BI	70-58.0	160-46.0	269	07	30	77	03.2	051	48	3	-3	00	0		05	2	156	5.6	4.9	1	4	2	6
31	BI	71-00.5	160-31.5	269	07	30	77	04.4	052	51	3	3	00	0		02	2	156	5.6	4.7	1	3	2	6
31	BI	71-07.5	160-15.0	269	07	30	77	07.5	053	52	3	6	00	0		36	3	157	5.5	4.6	4	3	2	6
31	BI	71-09.6	160-10.0	269	07	30	77	07.9	054	56	3	7	00	0		06	4	162	2.9	2.3	1	3	2	6
31	BI	71-13.6	160-00.1	269	07	30	77	08.8	055	52	3	1	00	0		03	3	163	3.7	3.0	4	3	1	6
31	BI	71-05.8	159-23.0	268	07	30	77	09.8	056	54	3	0	00	0		01	4	163	3.4	3.0	4	3	2	6
31	BI	71-10.8	159-26.5	268	07	30	77	10.8	057	47	3	0	00	0		02	4	161	3.7	3.1	4	3	2	6
31	BI	71-15.2	159-31.0	268	07	30	77	11.6	058	49	1	0	00	0		04	3	166	3.0	2.5	1	3	2	6
31	BI	71-12.2	159-12.0	268	07	30	77	13.0	059	48	3	0	03	0		03	4	167	4.6	4.0	4	3	4	6
31	BI	71-21.8	159-19.3	268	07	30	77	14.6	060	47	3	0	00	0		02	4	168	3.0	2.7	1	3	5	7

MIZPAC 77 CTD STATIONS

NAT	SHIP	LAT	LONG	MSQ	MO	DY	YR	HR	STA	DPTH	COD	IC	WVD	HT	PER	WND	V	BAR	DRY	WET	WTHR	CL	AMT	VIS
31	8I	71-26.5	159-20.1	268	07	30	77	15.7	061	50	3	0	00	0		03	4	169	3.2	2.6	4	3	4	6
31	8I	71-43.0	159-51.0	268	07	30	77	17.1	062	49	3	0	00	0		03	4	171	1.9	1.3	1	3	2	6
31	8I	71-43.0	159-25.0	268	07	30	77	18.6	063	50	3	0	00	0		03	4	173	2.8	2.2	2	7	6	6
31	8I	71-43.0	158-46.0	268	07	30	77	21.3	064	54	3	0	00	0		07	4	174	3.8	3.2	2	7	6	6
31	8I	71-30.0	159-00.0	268	07	30	77		065H		1													
31	8I	71-33.3	158-57.0	268	07	30	77		066H		1													
31	8I	71-38.0	158-49.0	268	07	30	77		067H		1													
31	8I	71-42.0	158-39.0	268	07	30	77		068H		1													
31	8I	71-47.2	158-34.0	268	07	30	77		069H		1													
31	8I	71-52.1	158-26.0	268	07	30	77		070H		1													
31	8I	71-41.0	158-10.0	268	07	30	77		071H		1													
31	8I	71-38.0	158-48.0	268	07	30	77	23.0	072	54	3	0	00	0		03	4	174	3.4	3.0	1	3	3	6
31	8I	71-33.6	158-46.2	268	07	31	77	00.6	073	54	3	0	00	0		04	4	172	4.4	3.8	1	3	5	6
31	8I	71-30.0	158-28.0	268	07	31	77	02.4	074	58	1	0	00	0		04	4	169	4.6	4.0	1	3	3	7
31	8I	71-35.0	158-28.0	268	07	31	77	03.5	075	57	3	0	00	0		04	5	171	5.0	4.0	1	8	3	7
31	8I	71-40.0	158-18.0	268	07	31	77	04.8	076	55	3	0	00	0		05	4	171	3.2	2.8	1	8	3	7
31	8I	71-45.0	158-18.0	268	07	31	77	06.1	077	59	3	1	00	0		04	4	171	3.3	2.8	1	8	3	6
31	8I	71-53.0	158-16.5	268	07	31	77	07.4	078	55	3	4	00	0		04	4	175	2.0	1.8	1	8	3	6
31	8I	71-52.0	157-56.0	268	07	31	77	10.0	079	61	3	1	00	0		05	5	174	2.3	1.8	1	8	2	6
31	8I	71-46.0	157-57.0	268	07	31	77	11.0	080	62	3	0	04	1		05	5	173	3.9	3.0	1	8	2	6

MIZPAC 77 CTD STATIONS

NAT	SHIP	LAT	LONG	MSQ	MO	DY	YR	HR	STA	DPTH	COD	IC	WVD	HT	PER	WND	V	BAR	DRY	WET	WTHR	CL	AMT	VIS
31	BI	71-39.0	158-00.0	268	07	31	77	12.3	081	65	3	0	00	0		04	5	169	3.6	3.0	1	8	2	6
31	BI	71-33.0	158-01.0	268	07	31	77	13.3	082	64	3	0	05	1		05	5	168	3.0	2.7	1	3	1	6
31	BI	71-28.0	158-03.0	268	07	31	77	14.3	083	112	3	0	06	1		06	5	167	3.0	2.7	1	3	2	6
31	BI	71-22.5	158-06.0	268	07	31	77	15.4	084	99	3	1	00	0		09	3	165	2.0	1.6	1	3	1	6
31	BI	71-23.1	157-32.4	268	07	31	77	17.0	085	117	3	1	00	0		08	5	166	2.8	2.2	1	3	1	6
31	BI	71-27.2	157-33.5	268	07	31	77	18.1	086	99	1	0	00	0		07	2	172	2.8	2.3	1	4	5	6
31	BI	71-31.5	157-32.5	268	07	31	77	19.0	087	72	3	0	00	0		04	4	174	3.4	3.2	1	4	5	6
31	BI	71-35.0	157-29.0	268	07	31	77	23.0	088	75														
31	BI	71-25.0	157-54.0	268	08	01	77	01.1	089H		1													
31	BI	71-19.9	158-21.0	268	08	01	77	01.3	090H		1	1												
31	BI	71-14.5	158-47.0	268	08	01	77	01.6	091H		1	1												
31	BI	71-24.4	158-47.5	268	08	01	77	01.8	092H		1													
31	BI	71-29.5	158-20.1	268	08	01	77	02.1	093H		1													
31	BI	71-34.8	157-53.0	268	08	01	77	02.3	094H		1													
31	BI	71-39.8	157-25.5	268	08	01	77	02.6	095H		1													
31	BI	71-29.0	157-25.0	268	08	01	77	03.8	096	107	3	0	00	0		04	4	165	3.2	3.1	0			6
31	BI	71-29.0	157-25.0	268	08	01	77	05.7	097	107	3	0	00	0		04	4	165	3.2	3.1	0			6
31	BI	71-36.8	157-24.0	268	08	01	77	07.2	098	64	3	0	00	0		06	3	165	2.7	2.3	1	0	3	6
31	BI	71-42.0	157-24.8	268	08	01	77	08.0	099	63	3	0	00	0		05	3	166	2.9	2.6	1	0	3	6
31	BI	71-47.0	157-24.5	268	08	01	77	09.1	100	66	3	0	00	0		05	3	167	2.5	2.2	1	0	3	6

MIZEAC 77 CTD STATIONS

NAT	SHIP	LAT	LONG	MSQ	MO	CY	YR	HR	STA	DPTH	CCD	IC	WVD	FT	PER	WND	V	BAR	DRY	WET	WTHR	CL	AMT	VIS
31	BI	71-53.0	157-24.0	268	08	01	77	10.0	101	72	3	2	00	0		05	3	167	2.0	1.5	1	0	3	6
31	BI	71-45.0	157-50.0	268	08	01	77	12.4	102	62	3	0	00	0		05	3	166	2.8	2.5	1	0	3	6
31	BI	71-45.0	158-18.0	268	08	01	77	13.7	103	56	3	0	00	0		29	3	166	2.2	1.8	1	0	3	6
31	BI	71-45.0	158-49.0	268	08	01	77	16.1	104	54	3	0	00	0		06	3	167	2.8	2.2	1	0	4	6
31	BI	71-25.0	159-01.0	268	08	01	77	17.6	105	54	1	0	00	0		07	3	170	5.3	4.9	1	0	1	6
31	BI	71-21.0	158-53.0	268	08	01	77	19.1	106	54	1	-3	00	0		24	2	173	7.8	6.0	1	0	1	6
31	BI	71-24.5	158-21.0	268	08	01	77	21.3	107	114	1	2	00	0		08	1	172	6.6	5.9	1	0	1	6
31	BI	71-26.8	157-30.0	268	08	01	77	23.7	108	108	1	2	00	0		09	1	172	7.0	6.0	1	0	1	6
31	BI	71-23.9	158-03.0	268	08	02	77	06.8	109	96	1	-4	00	0		11	5	164	4.3	4.0	1	0	1	6
31	BI	71-28.5	158-00.0	268	08	02	77	07.8	110	72	1	0	00	0		12	5	163	5.6	5.0	1	0	2	6
31	BI	71-35.0	158-00.0	268	08	02	77	08.8	111	63	1	0	00	0		13	5	162	6.0	5.3	1	0	2	6
31	BI	71-41.5	158-08.8	268	08	02	77	10.2	112	63	1	0	15	0		15	5	162	5.8	5.0	1	0	5	6
31	BI	71-44.0	158-02.0	268	08	02	77	11.0	113	60	1	-7	15	0		15	5	155	4.8	4.2	1	0	7	6
31	BI	71-49.4	158-00.5	268	08	02	77	12.0	114	63	1	0	16	0		16	5	156	4.6	4.2	1	0	4	6
31	BI	71-55.9	157-57.0	268	08	02	77	13.3	115	70	2	1	00	0		15	4	154	4.7	4.3	1	0	4	6
31	BI	71-50.0	158-48.0	268	08	02	77	16.2	116	55	3	-6	00	0		15	4	136	5.3	5.0	1	0	5	6
31	BI	71-35.0	159-00.0	268	08	02	77	21.1	117	53	3	0	00	0		26	4	138	5.5	4.8	1	0	7	6
31	BI	71-35.0	158-44.0	268	08	02	77	22.2	118	54	3	0	00	0		25	4	143	5.8	5.2	1	0	7	6
31	BI	71-35.0	158-29.5	268	08	02	77	23.1	119	58	3	0	00	0		17	4	146	6.1	5.8	1	0	7	6
31	BI	71-35.0	158-11.5	268	08	03	77	00.1	120	62	3	0	00	0		17	4	150	5.8	5.3	1	0	7	6

MIZPAC 77 CTD STATIONS

NAT	SHIP	LAT	LONG	MSQ	MO	DY	YR	HR	STA	DPTH	COD	IC	WVD	HT	PER	WND	V	BAR	DRY	WET	WTHR	CL	AMT	VIS
31	BI	71-37.4	157-54.9	268	08	03	77	01.0	121	63	2	0	00	0		26	4	151	5.3	5.2	4	X	9	1
31	BI	71-35.1	157-38.2	268	08	03	77	01.8	122	63	3	0	00	0		21	4	155	4.6	4.6	4	X	9	0
31	BI	71-35.0	157-19.6	268	08	03	77	02.7	123	73	3	0	00	0		26	4	157	4.0	3.8	4	X	9	1
31	BI	71-22.3	158-07.1	268	08	03	77	05.6	124	90	3	1	00	0		24	3	162	4.1	3.8	4	X	9	2
31	BI	71-11.5	159-06.5	268	08	03	77	09.5	125	91	3	1	00	0		27	3	175	3.8	3.7	4	X	9	2
31	BI	71-10.8	158-54.0	268	08	03	77	11.2	126	98	1	5	00	0		29	3	178	3.6	3.5	4	X	9	1
31	BI	71-01.0	158-57.0	268	08	03	77	12.9	127	35	1	0	00	0		01	1	182	7.4	7.4	4	0	3	5
31	BI	70-57.0	158-53.5	268	08	03	77	14.3	128	19	1	0	00	0		03	2	182	8.7	8.4	4	8	6	5
31	BI	71-06.0	158-59.0	268	08	03	77	15.4	129	63	1	3	00	0		04	3	184	3.2	3.1	4	8	6	5
31	BI	70-52.0	159-40.0	268	08	03	77	18.2	130	31	1	0	00	0		15	2	186	10.0	9.7	4	7	7	6
31	BI	70-42.5	160-45.0	269	08	03	77	21.2	131	46	3	0	00	0		15	3	195	13.0	11.8	4	3	6	5
31	BI	70-35.5	161-41.0	269	08	04	77	00.9	132	34	1	0	00	0		25	2	177	16.1	15.0	4	0	2	2
31	BI	70-44.3	161-54.9	269	08	04	77	04.4	133	42	1	0	00	0		07	3	175	12.8	12.6	4	0	2	1
31	BI	70-53.2	162-12.8	269	08	04	77	05.7	134	43	1	0	00	0		08	3	173	11.8	11.5	4	0	2	6
31	BI	71-00.9	162-28.9	269	08	04	77	07.3	135	45	1	0	00	0		09	4	172	10.3	10.3	4	X	1	2
31	BI	71-10.0	162-39.8	269	08	04	77	08.9	136	46	1	0	00	0		10	3	170	9.0	9.0	4	X	9	1
31	BI	71-15.9	163-09.0	269	08	04	77	10.6	137	48	1	0	00	0		12	5	165	6.2	6.2	4	X	9	1
31	BI	71-11.6	162-23.5	269	08	04	77	12.4	138	45	1	0	00	0		11	5	159	9.0	8.9	4	X	9	5
31	BI	71-08.2	161-49.0	269	08	04	77	14.3	139	45	3	0	00	0		18	6	157	10.4	9.6	4	0	6	6
31	BI	71-15.0	161-25.5	269	08	04	77	15.6	140	49	3	0	00	0		13	5	157	7.6	7.2	4	X	9	5

MIZPAC 77 CTD STATIONS

NAT	SHIP	LAT	LONG	MSQ	MO	DY	YR	HR	STA	DPTH	COD	IC	WVD	HT	PER	WND	V	BAR	DRY	WET	WTHR	CL	AMT	VIS
31	BI	71-18.0	161-14.0	269	08	04	77	16.5	141	49	3	3	00	0		14	4	158	5.4	5.2	4	X	9	2
31	BI	71-19.3	161-08.5	269	08	04	77	17.4	142	50	1	2	00	0		18	5	160	5.1	4.8	4	X	9	2
31	BI	71-10.5	160-35.5	269	08	04	77	19.4	143	47	1	0	00	0		17	4	162	7.0	6.6	4	X	9	6
31	BI	71-02.5	160-16.0	269	08	04	77	20.6	144	51	3	0	00	0		16	3	165	10.5	9.5	4	7	7	4
31	BI	70-58.5	160-08.0	269	08	04	77	22.3	145	69	1	0	00	0		16	3	165	13.5	12.1	4	7	7	4
31	BI	70-54.0	159-58.0	268	08	04	77	23.2	146	54	1	0	00	0		22	4	169	14.5	13.0	4	7	7	3
31	BI	71-16.0	156-52.0	268	08	05	77	05.8	147	33	1	-3	00	0		11	3	168	6.7	7.2	1	0	2	6
31	BI	71-22.5	157-04.2	268	08	05	77	06.9	148	104	1	3	00	0		11	4	168	5.2	4.0	1	0	2	6
31	BI	71-24.8	157-12.0	268	08	05	77	07.9	149	143	1	1	00	0		02	3	171	4.6	4.4	0			6
31	BI	71-29.5	157-22.0	268	08	05	77	09.2	150	106	1	1	00	0		10	4	172	4.0	3.8	0			6
31	BI	71-28.0	156-30.0	268	08	05	77	11.6	151	139	1	0	00	0		08	4	170	4.0	3.8	1	0	1	6
31	BI	71-34.0	156-30.0	268	08	05	77	12.8	152	153	3	4	00	0		09	4	165	2.4	2.2	1	0	2	6
31	BI	71-39.0	156-28.5	268	08	05	77	14.1	153	130	1	0	00	0		07	5	170	4.1	3.8	1	0	0	6
31	BI	71-44.0	156-26.5	268	08	05	77	16.0	154	90	3	6	00	0		10	5	168	3.2	2.9	0			6
31	BI	71-40.0	156-23.0	268	08	05	77	16.3	155	108	3	1	00	0		07	5	163	3.9	3.0	1	0	0	6
31	BI	71-40.0	156-46.9	268	08	05	77	17.5	156	91	3	-4	00	0		08	5	160	5.1	4.0	1	0	2	6
31	BI	71-40.0	157-10.0	268	08	05	77	18.9	157	66	3	1	00	0		10	5	158	4.6	3.8	1	0	5	6

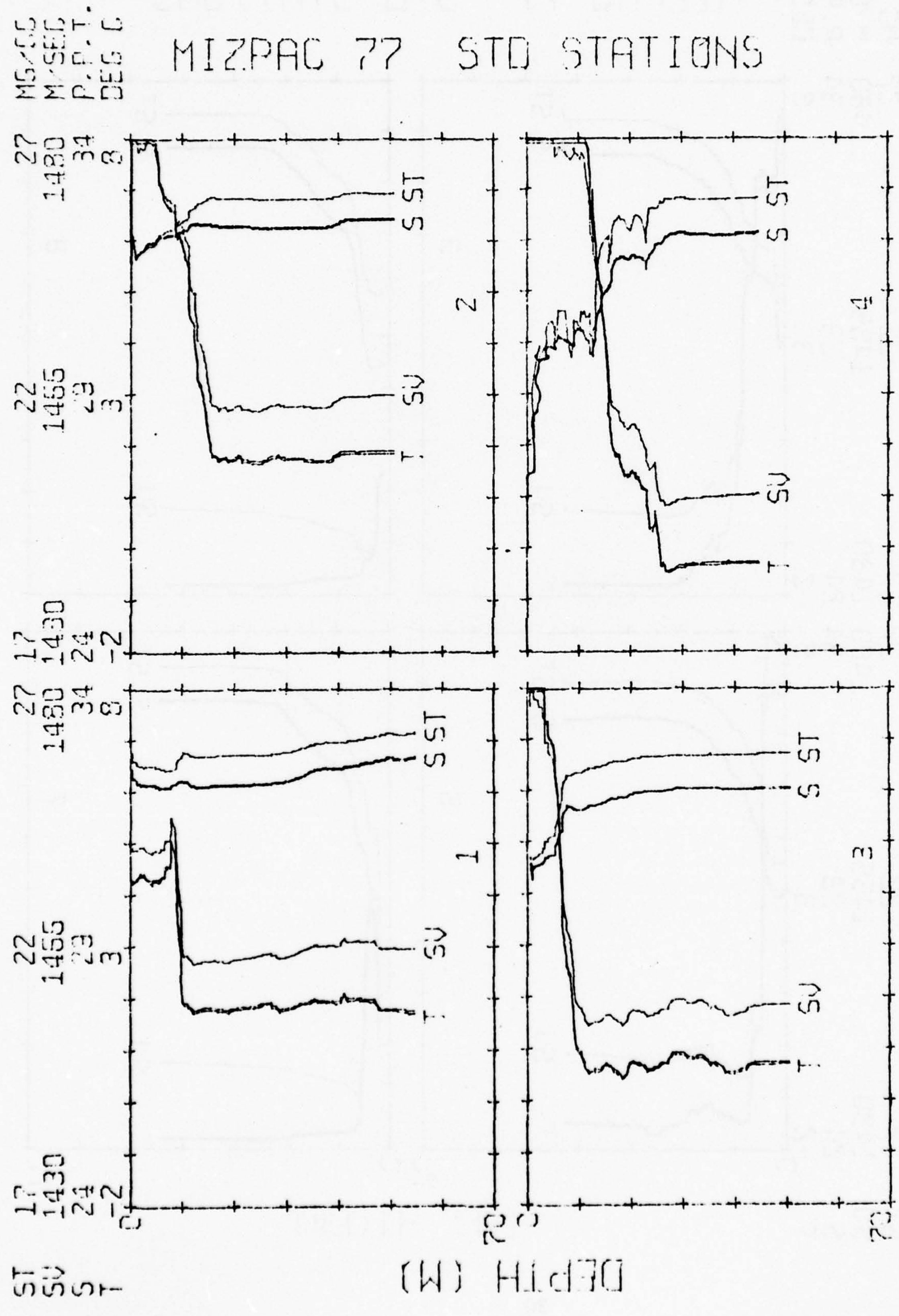
TOTAL= 157

APPENDIX D

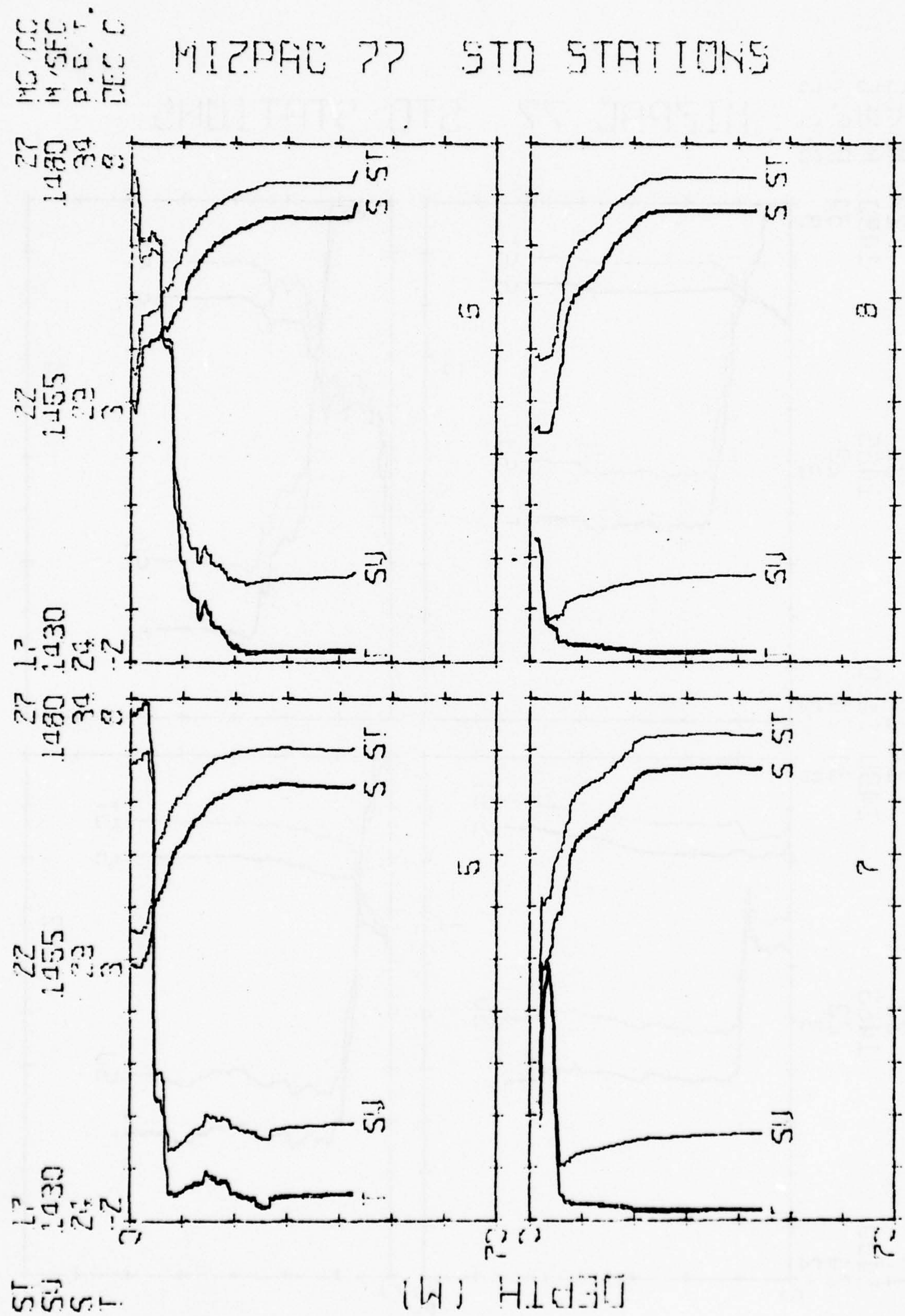
PROPERTY PROFILES FOR MIZPAC 77 STATIONS

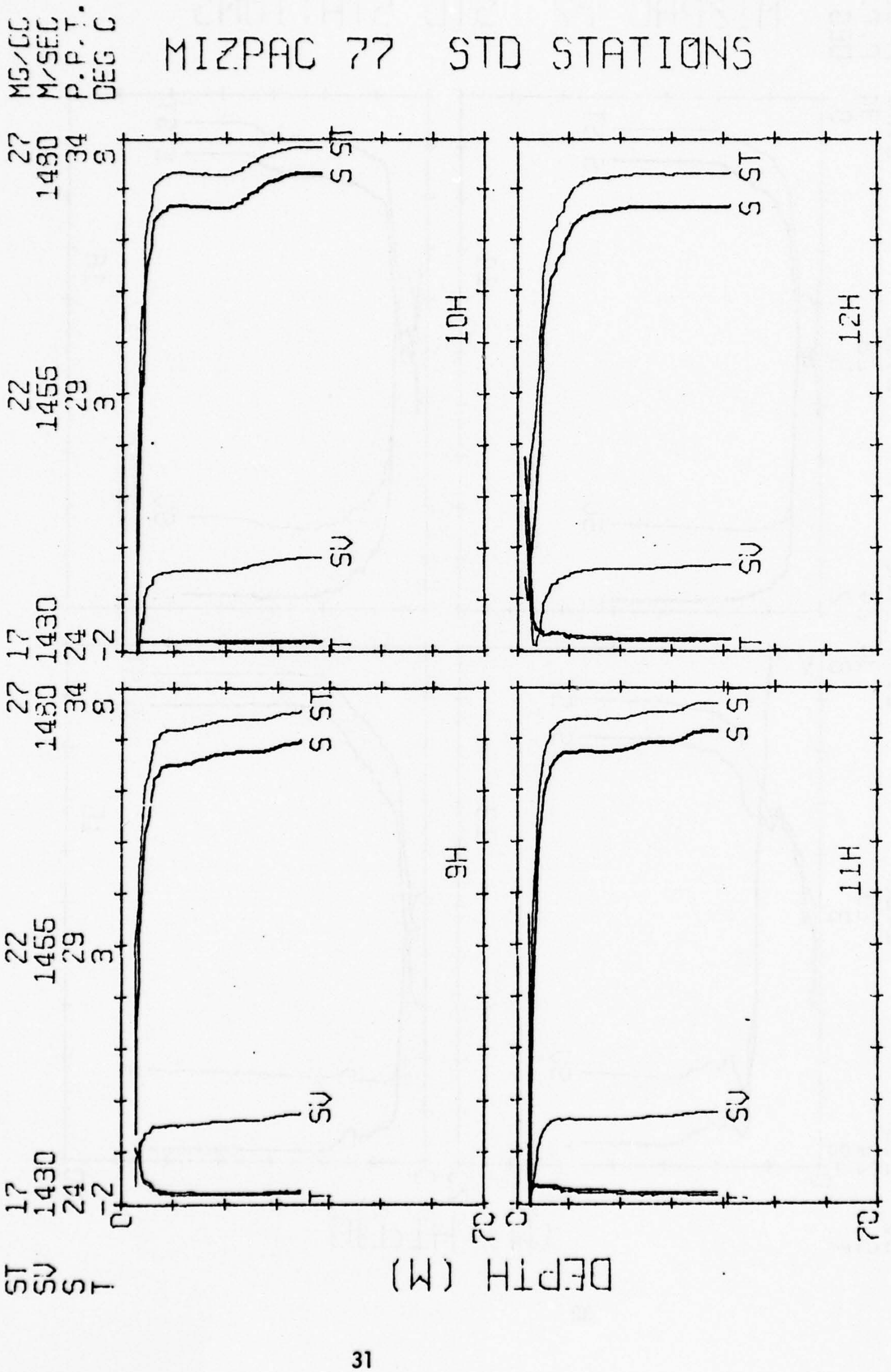
This section contains plots of temperature, salinity, sound velocity and sigma-t for all of the stations of MIZPAC 77 which were recovered from the cassette tapes successfully. Station 97 is missing and of the sequence 65H through 71H, allotted for a helicopter expedition, only the first two were successful. Other "H" suffixes also indicate helicopter stations. It will be noted that Stations 46 and 107 are duplicated. Explanations of the differences between duplicates are given in Appendix A.

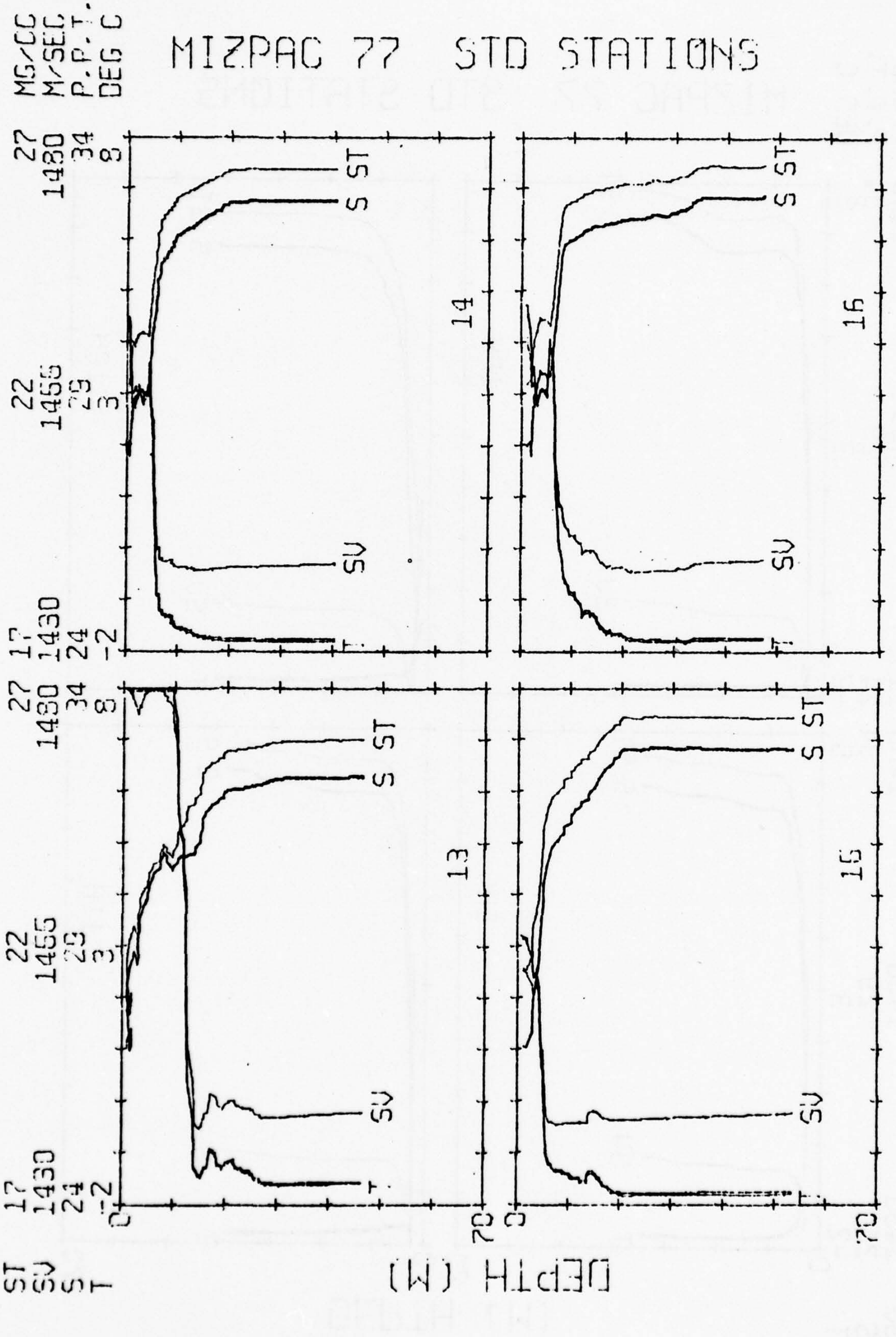
The basic four-per-page plot has a maximum depth of 70 m. All the stations were plotted in this way. In addition, deeper stations were plotted on a 140-meter depth scale, two per page. These are interleaved with the smaller plots. To assist in distinguishing curves the salinity curve has been doubled with a line 0.01 inches to the left and the temperature has been treated similarly with 0.015 inch spacing. The curves are also labeled, T for temperature, S for salinity, SV for sound velocity and ST for sigma-t.

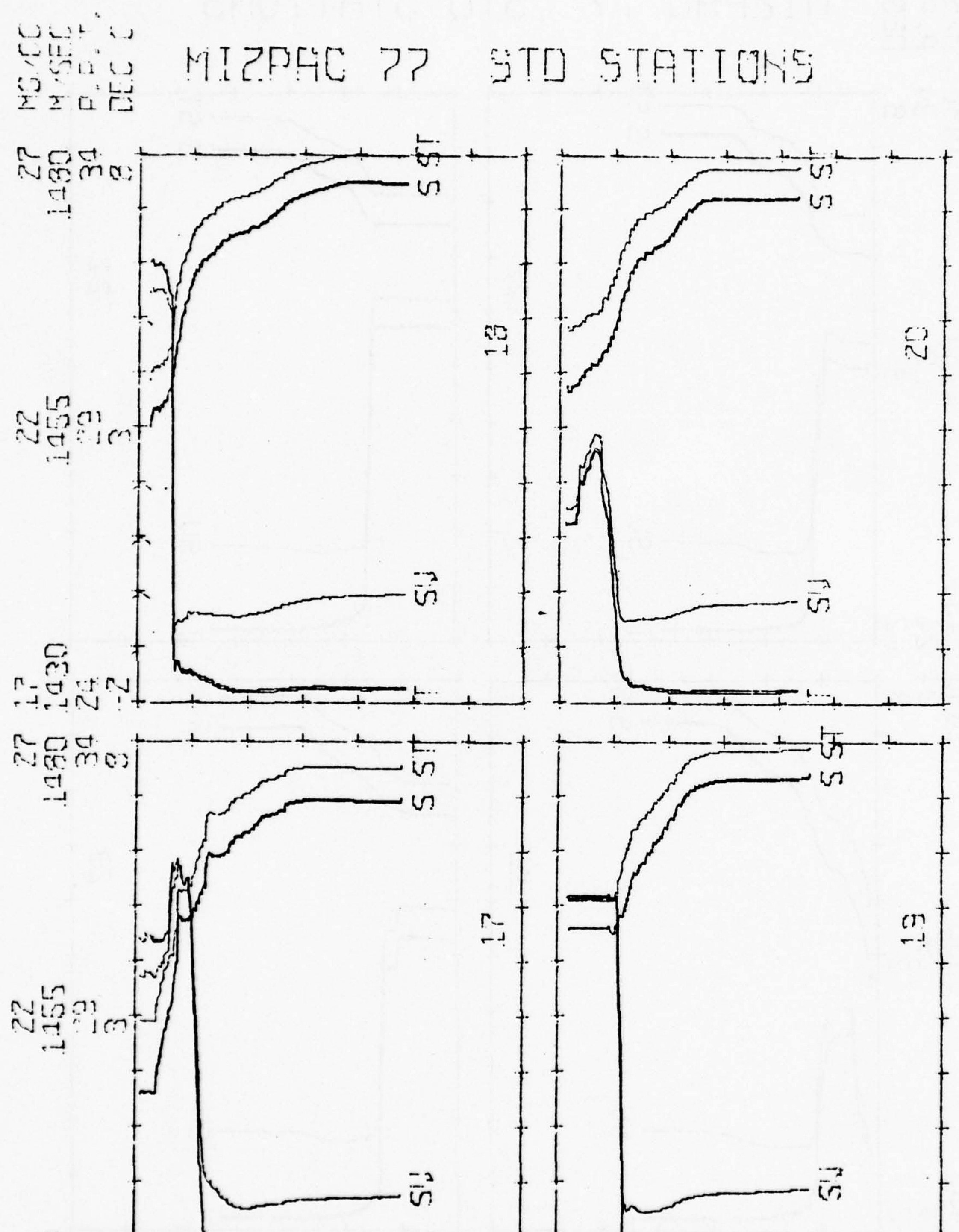


MIZPAC 77 STD STATIONS
MS/CC
M/SEC
P.P.T.
DEG C
27
1480
34
8
22
1455
29
3
17
1430
24
-2
S ST
S
SV
T
1
2
3
4
0
70
ST
SV
S
T
DEPTH (M)

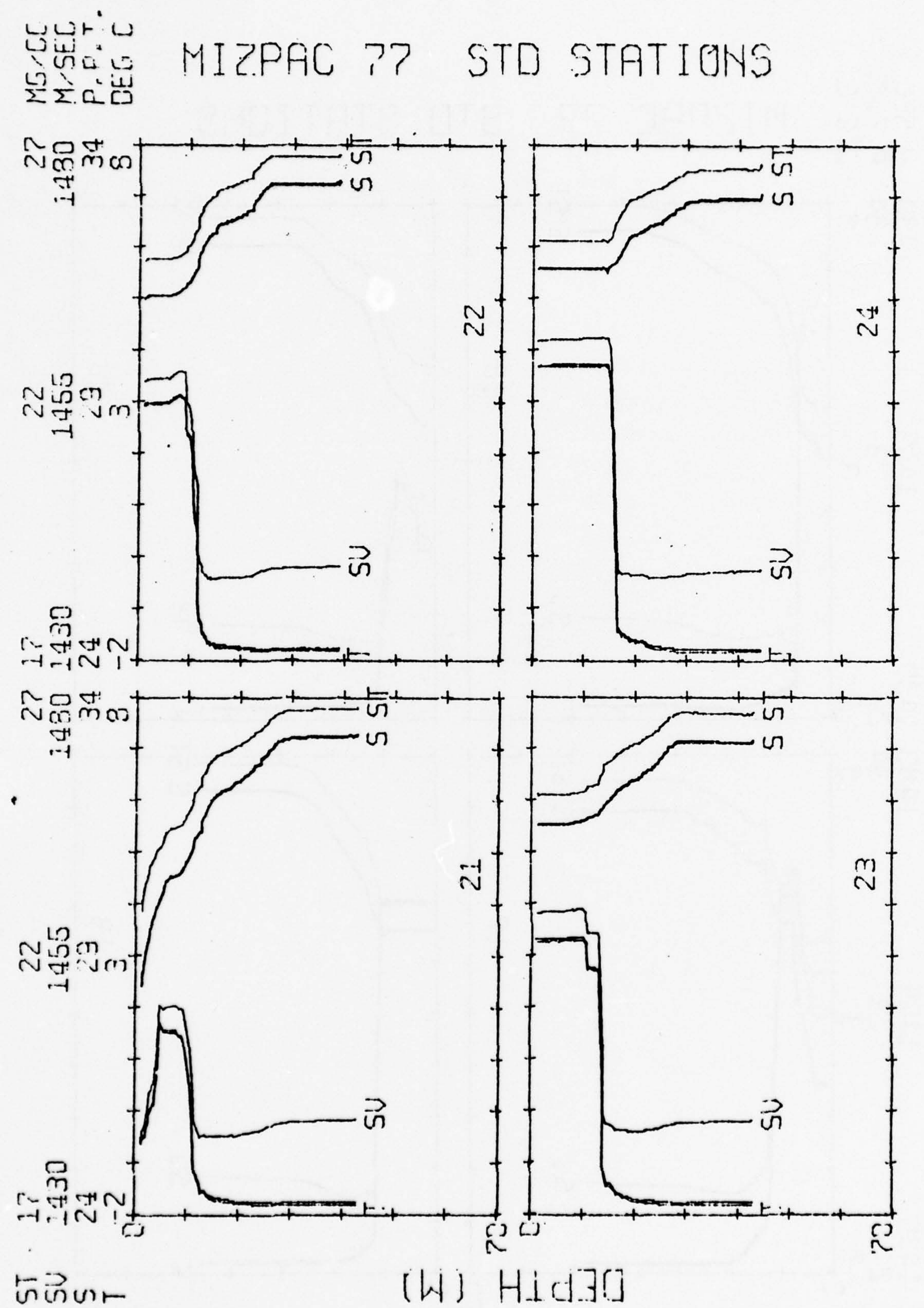

MIZPAC 77 STD STATIONS
DEPTH (M)

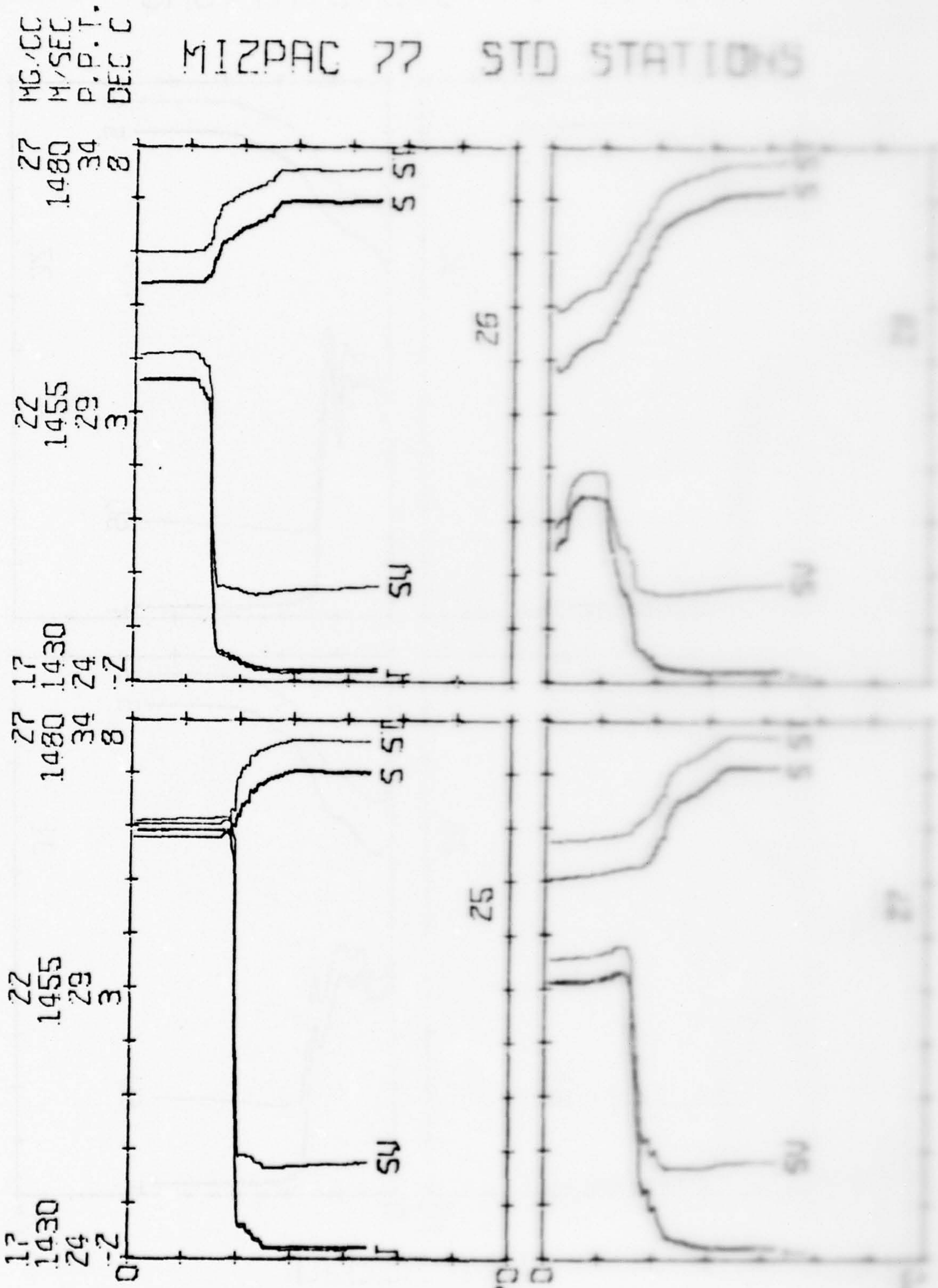

MIZPAC 77 STD STATIONS
ST SV S T
17 1430 24 -2
22 1455 29 3
27 1480 34 8
MG/CC M/SEC P.P.T. DEG C
DEPTH (M)
0
70
9H
10H
11H
12H
T SV S ST


MIZPAC 77 STD STATIONS
MG/CC
M/SEC
P.P.T.
DEG C
27
1430
34
9
22
1455
29
3
17
1430
24
-2
S ST
S
SV
T
14
16
13
15
0
70
ST
SV
S
T
DEPTH (M)

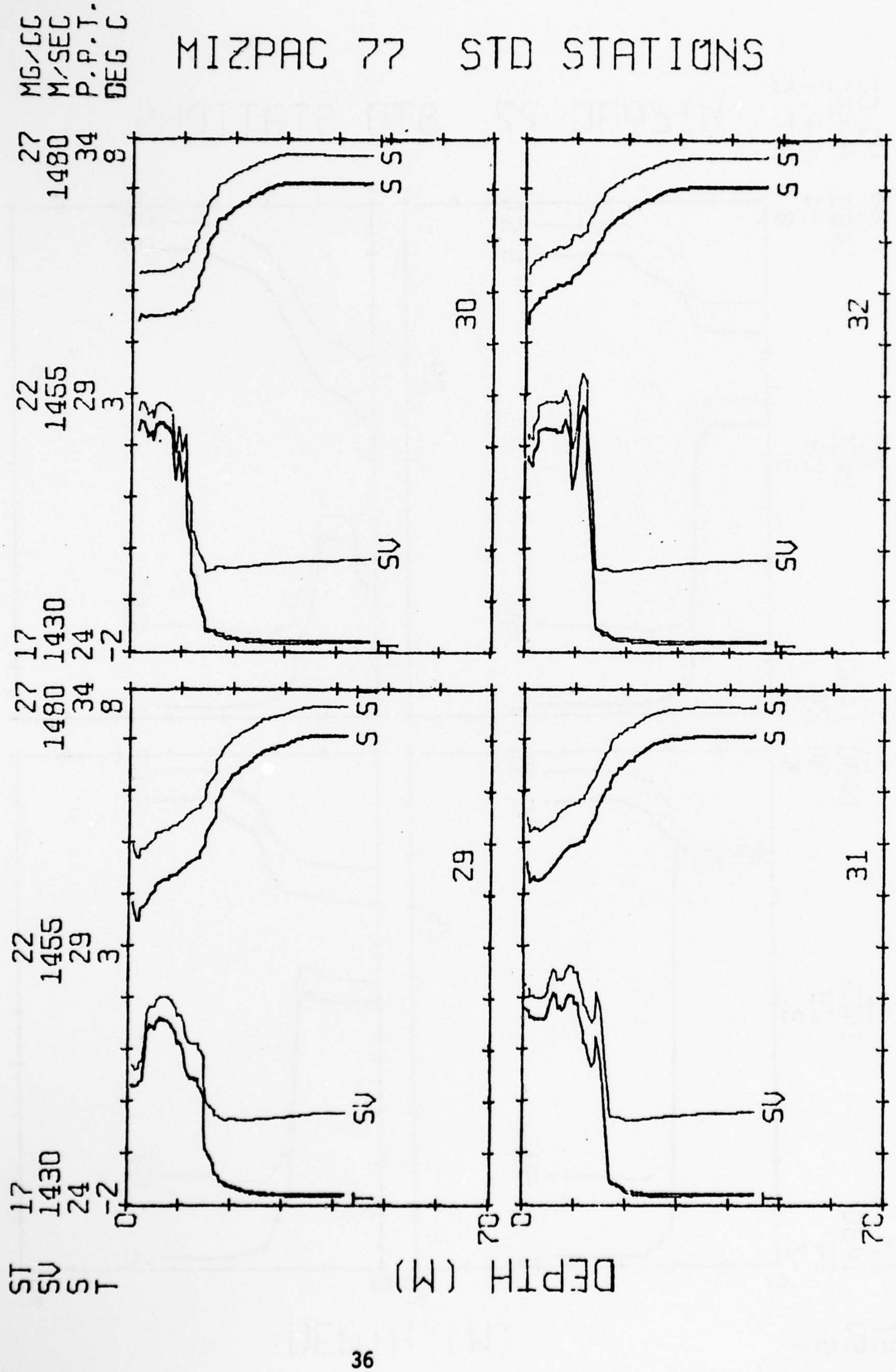


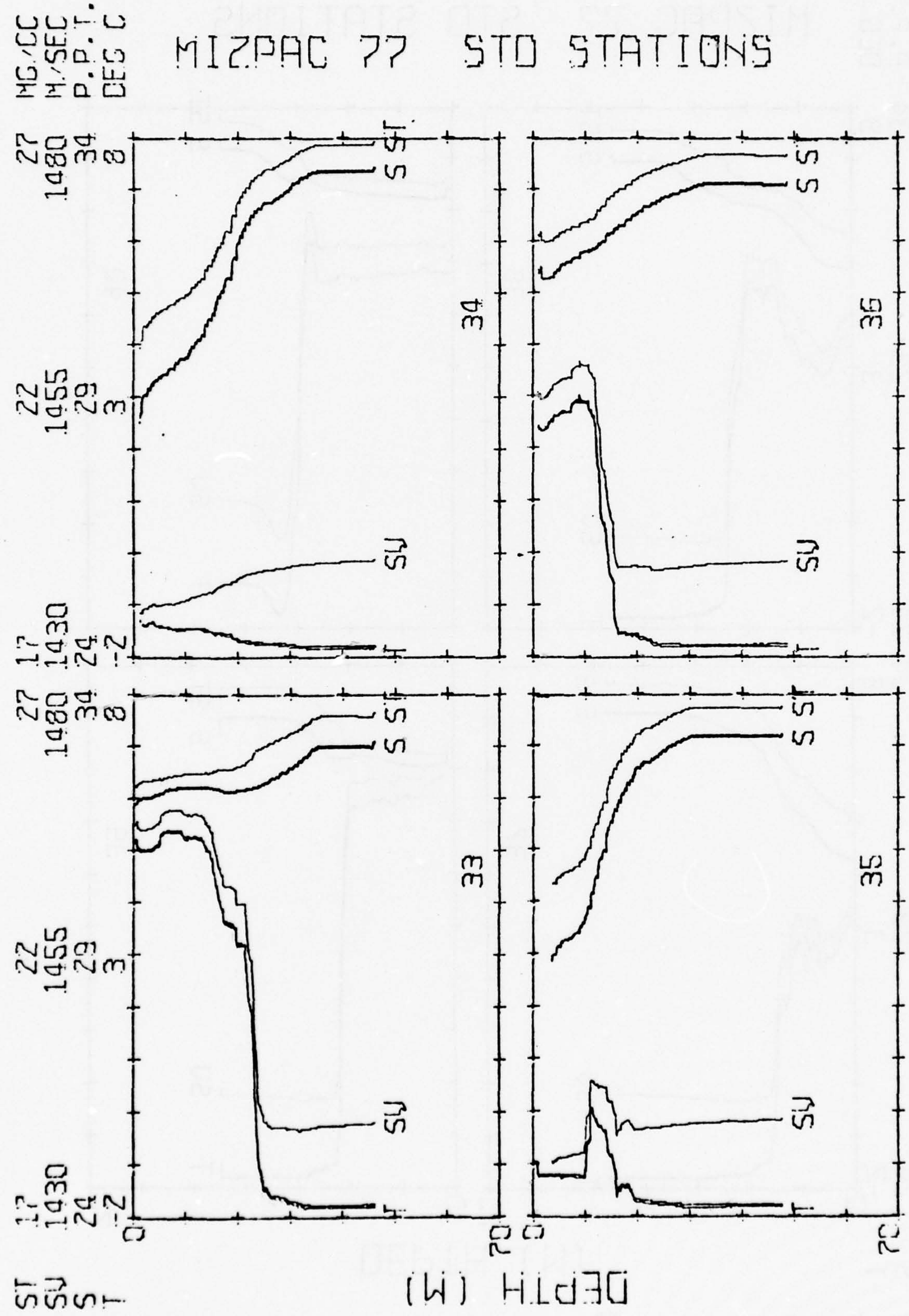
MIZPAC 77 STD STATIONS
ST
SV
S
T
17
1430
24
-2
22
1455
29
3
27
1480
34
8
MG/CC
M/SEC
P.P.T.
DEC C
DEPTH (M)
0
70
17
18
19
20
SV
S
ST
T

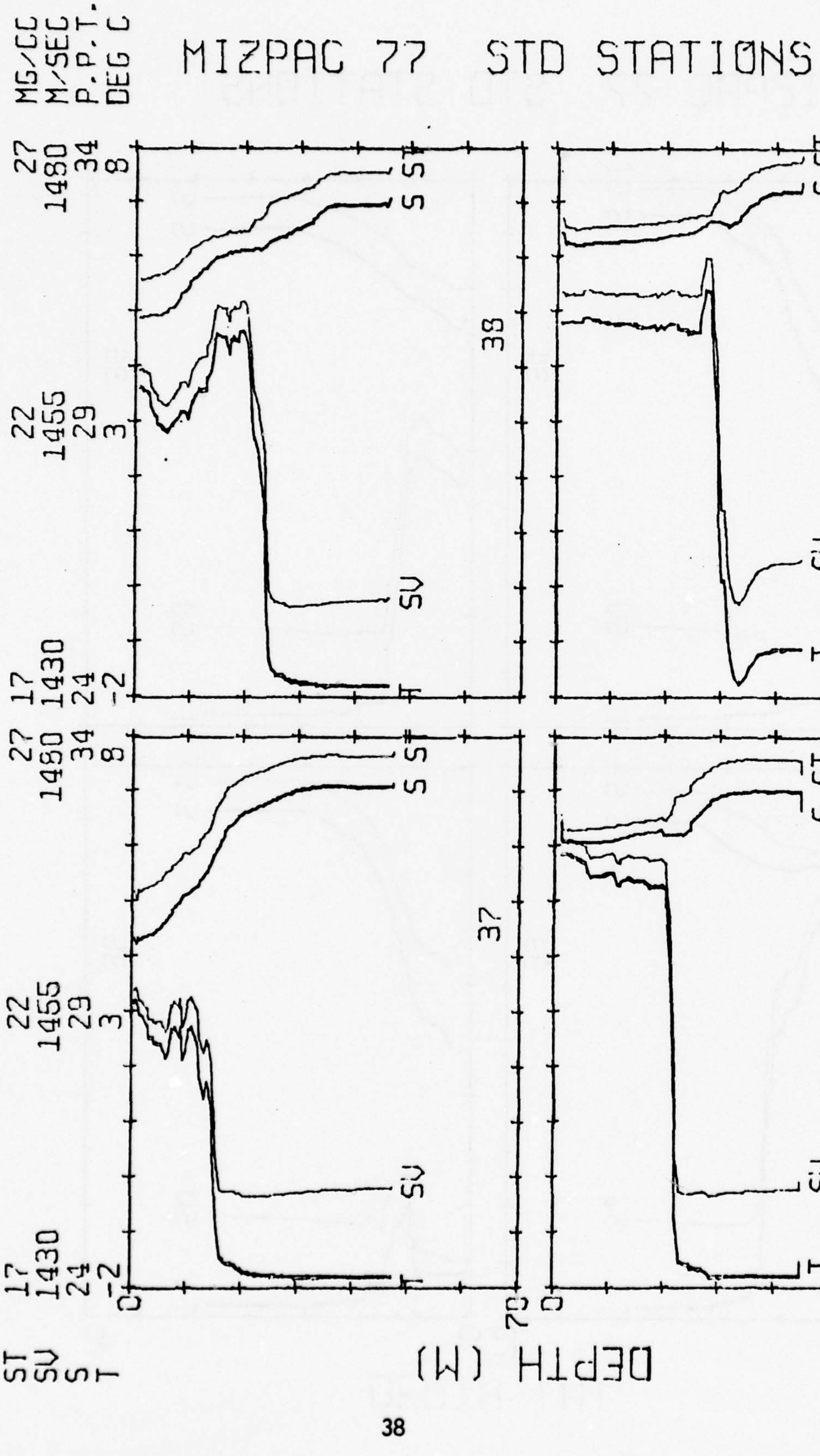

MIZPAC 77 STD STATIONS
MS/CC
M/SEC
P.P.T.
DEG. C
27 1430 34 8
22 1455 29 3
17 1430 24 -2
21
22
23
24
S ST
S
SV
T
0
70
DEPTH (M)
ST
SV
S
T

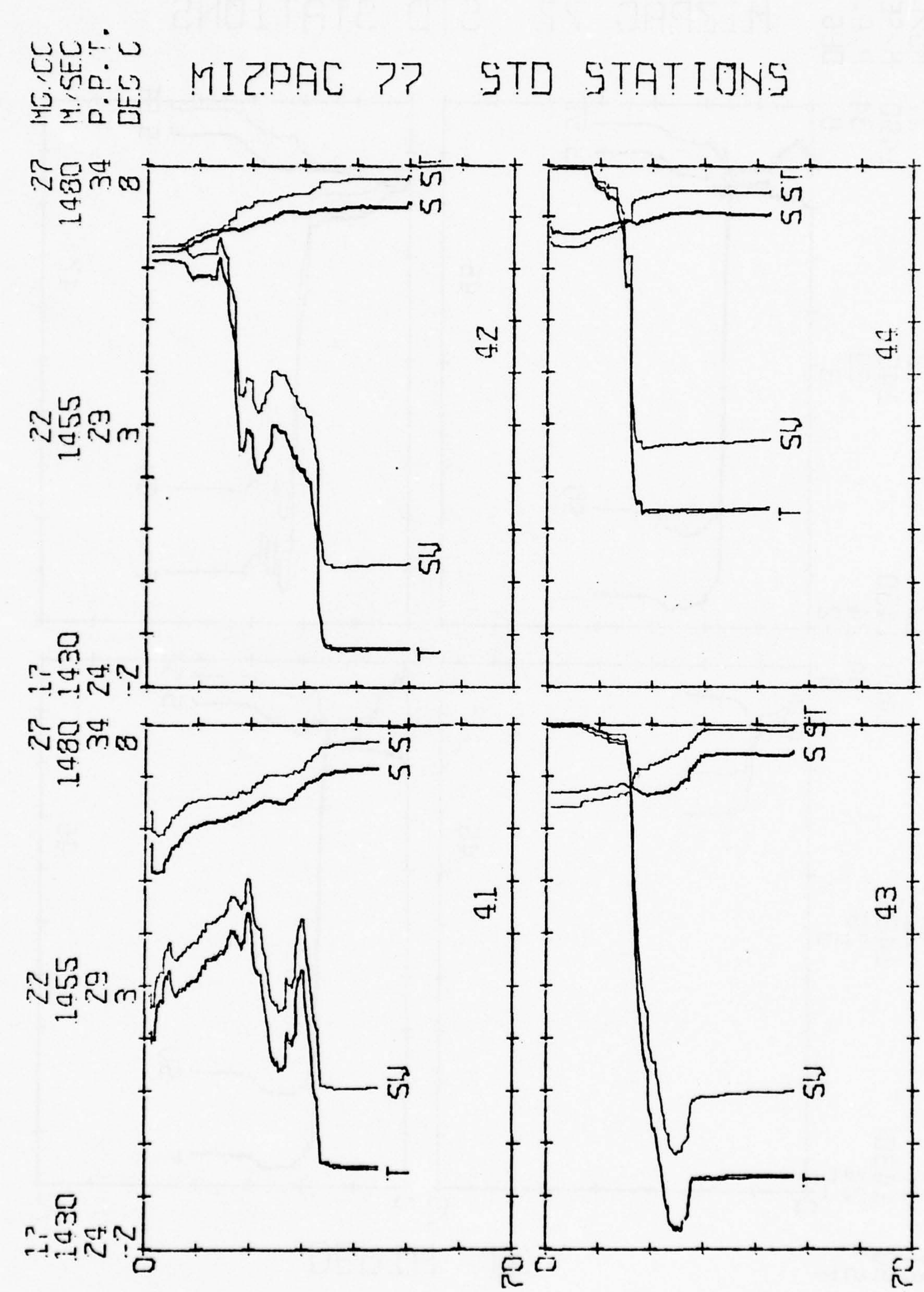


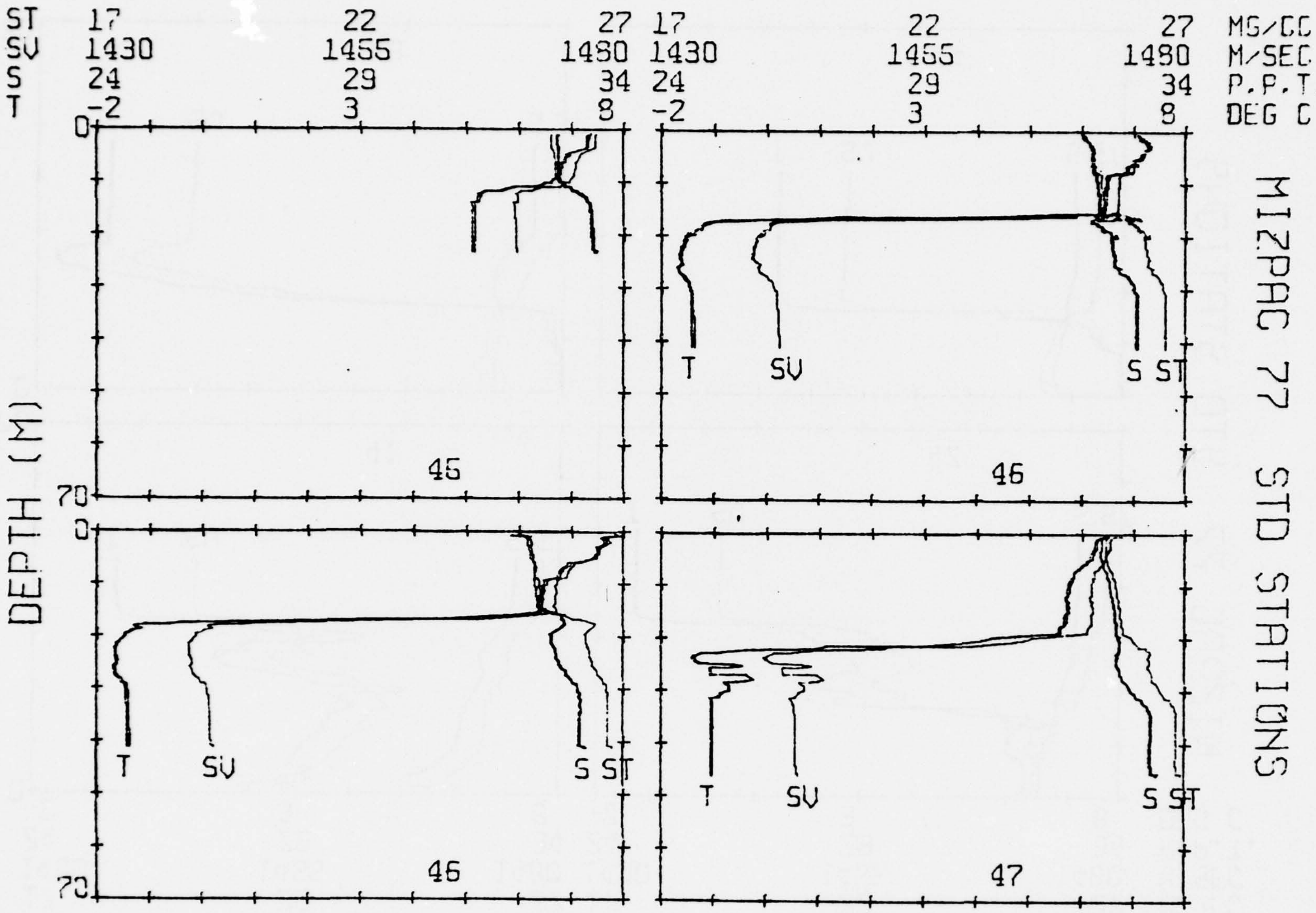
MIZPAC 77 STD STATIONS
MG/CC
M/SEC
P.P.T.
DEG C
ST
SV
S
T
DEPTH (M)
26
25
27
1480
1455
1430

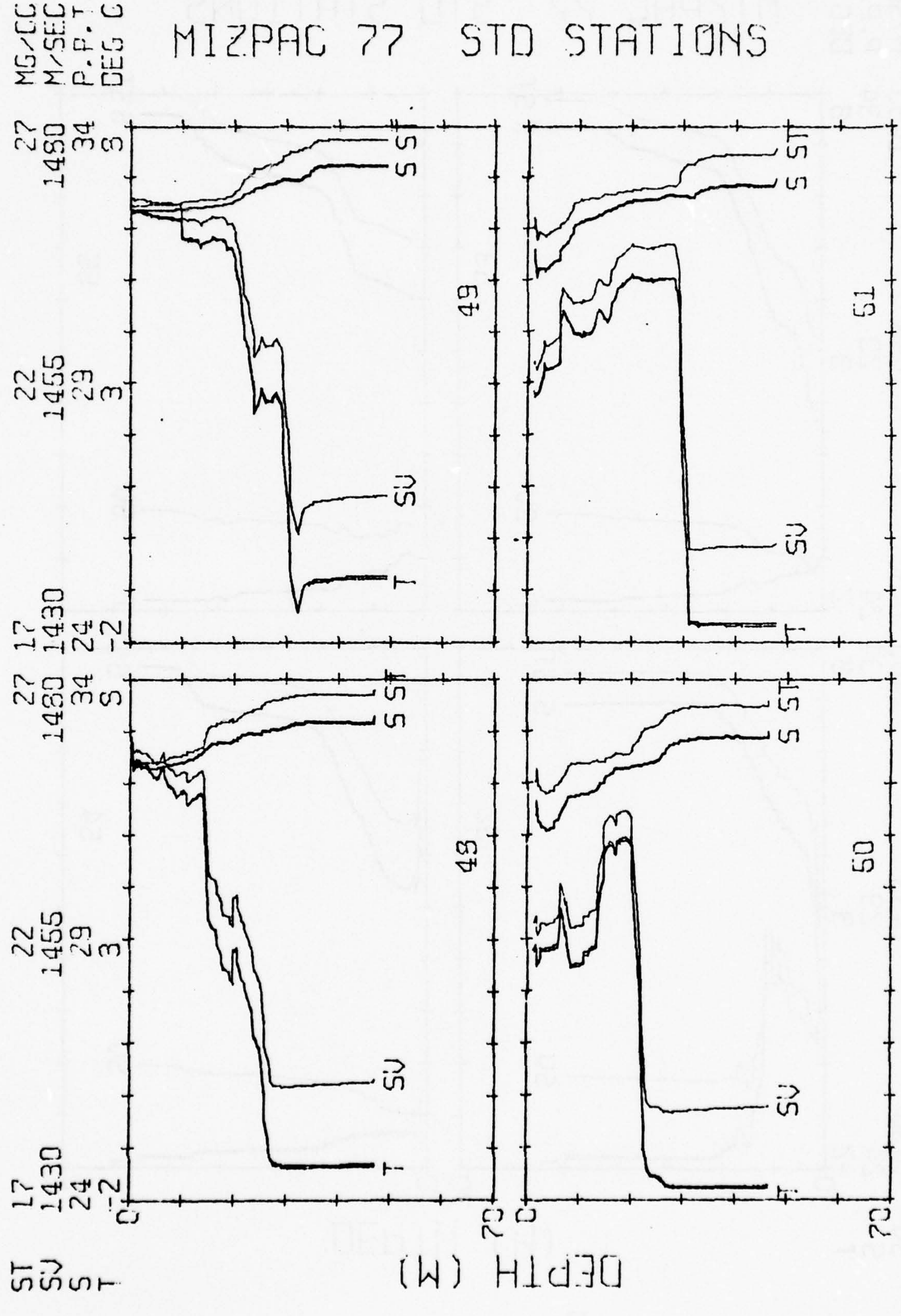

MIZPAC 77 STD STATIONS
ST SV S T
17 1430 24 -2
22 1455 29 3
27 1480 34 8
MG/CC M/SEC P.P.T. DEG C
S ST
SV
T
29
30
31
32
0
70
DEPTH (M)

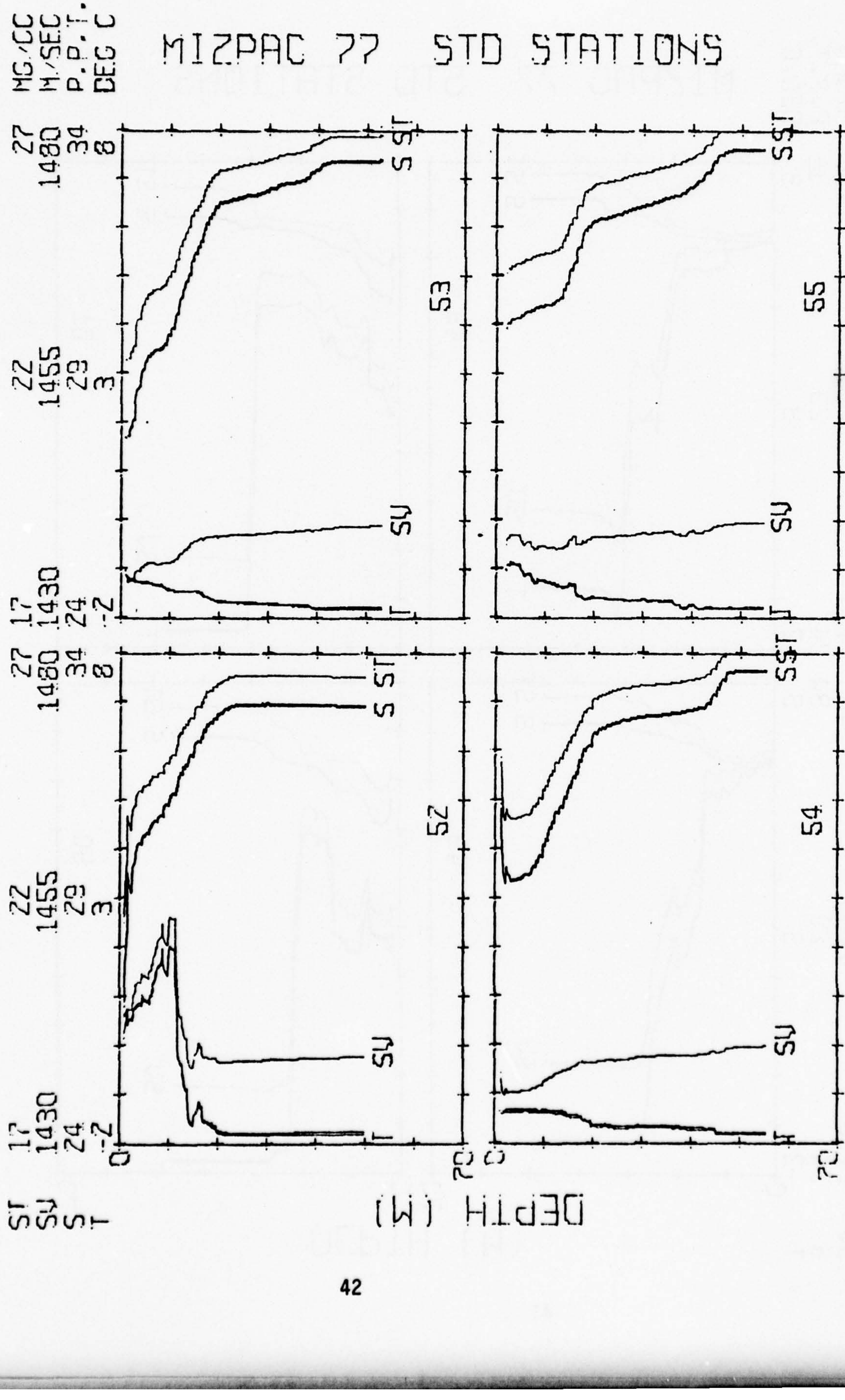

MIZPAC 77 STD STATIONS
MG/CC
M/SEC
P.P.T.
DEG C
27 1480 34 8
22 1455 29 3
17 1430 24 -2
ST
SV
S
T
S ST
SV
33
34
35
36
0
70
DEPTH (M)

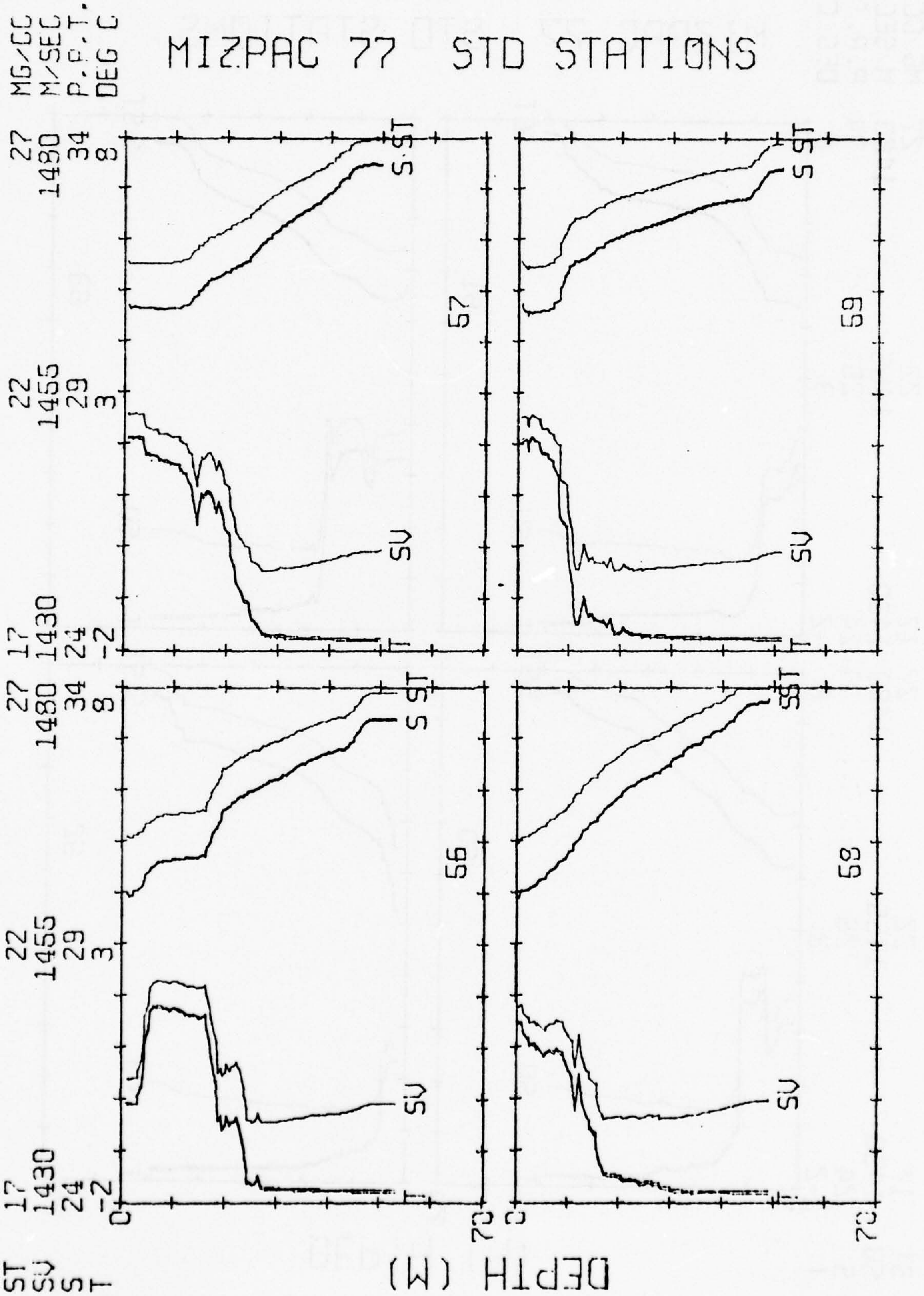

MIZPAC 77 STD STATIONS
ST MG/CC
SV M/SEC
S P.P.T.
T DEG C
DEPTH (M)
37
38
39
40


MIZPAC 77 STD STATIONS
ST MG/CC 17 22 27
SV M/SEC 1430 1455 1480
S P.P.T. 24 29 34
T DEG C -2 3 8
DEPTH (M)
0
20
41
42
43
44
S ST
SV
T

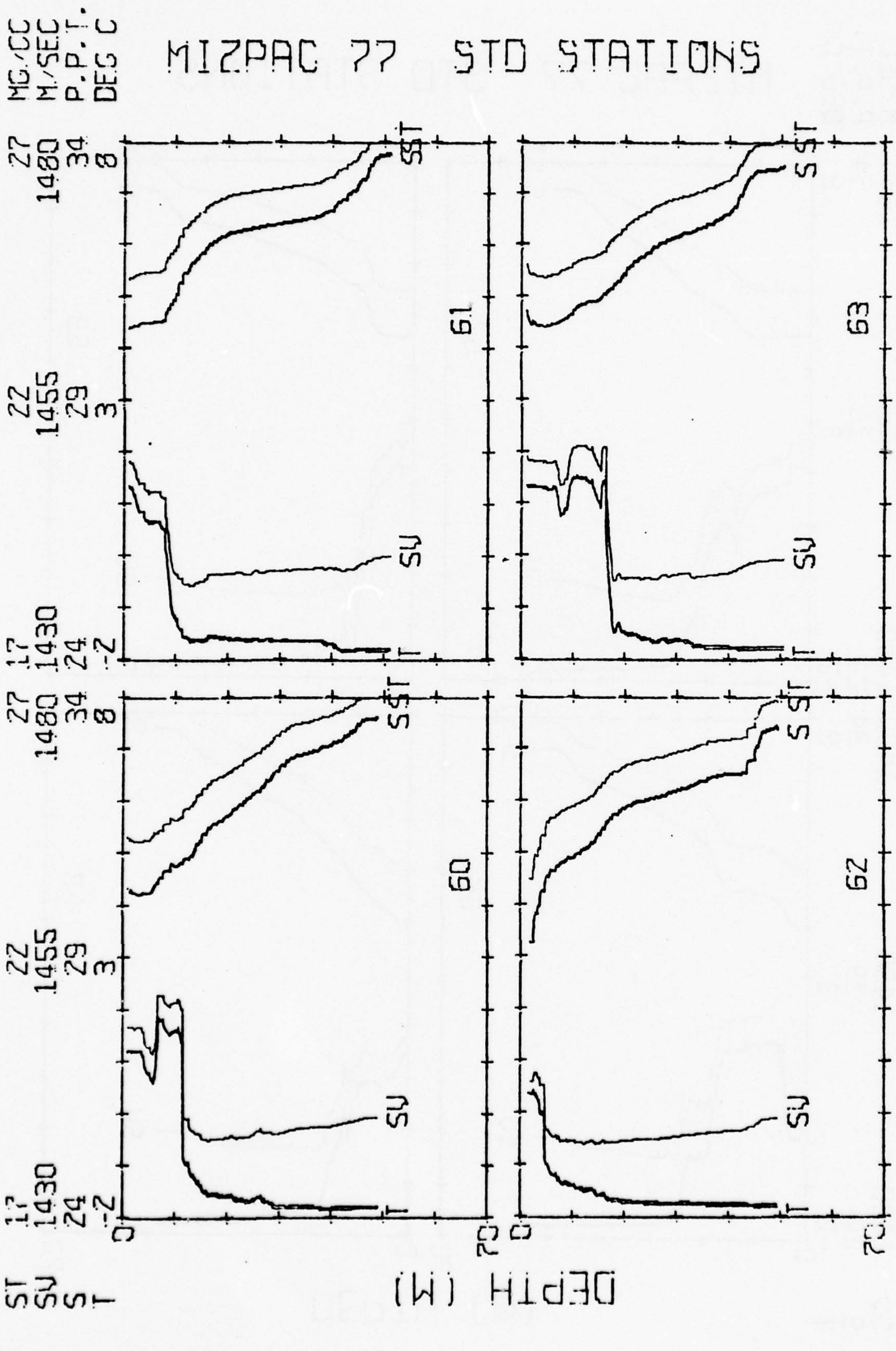

MIZPAC 77 STD STATIONS
ST 17 22 27 MG/CC
SV 1430 1455 1480 M/SEC
S 24 29 34 P.P.T.
T -2 3 8 DEG C
DEPTH (M)
0
70
45
46
46
47
T
SV
S
ST


MIZPAC 77 STD STATIONS
MG/CC
M/SEC
P.P.T.
DEG C
27 1480 34 8
22 1455 29 3
17 1430 24 -2
49
51
48
50
S ST
S
SV
T
ST
SV
S
T
0
70
DEPTH (M)

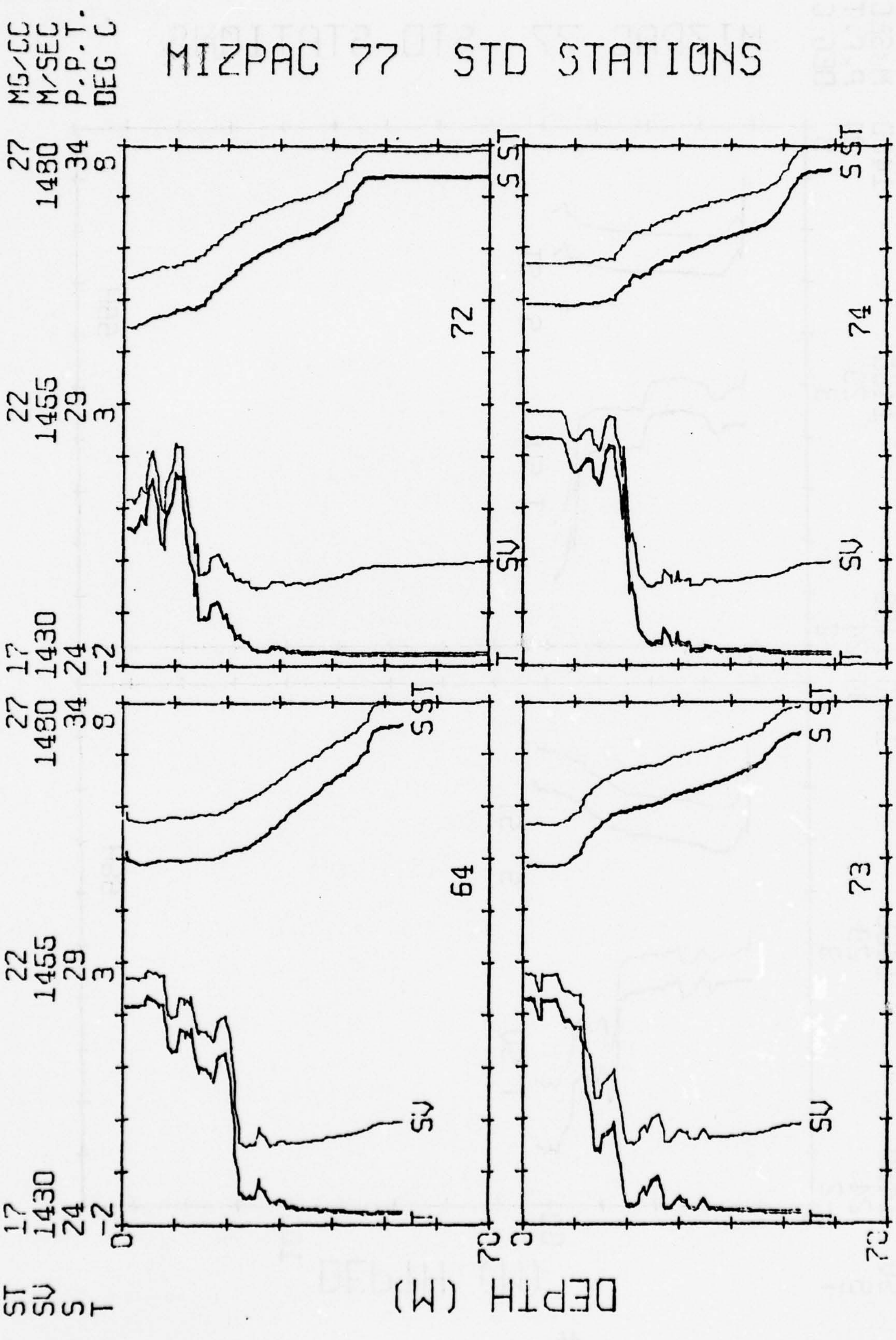

MIZPAC 77 STD STATIONS
MG/CC
M/SEC
P.P.T.
DEG C
ST
SV
S
T
DEPTH (M)
52
53
54
55

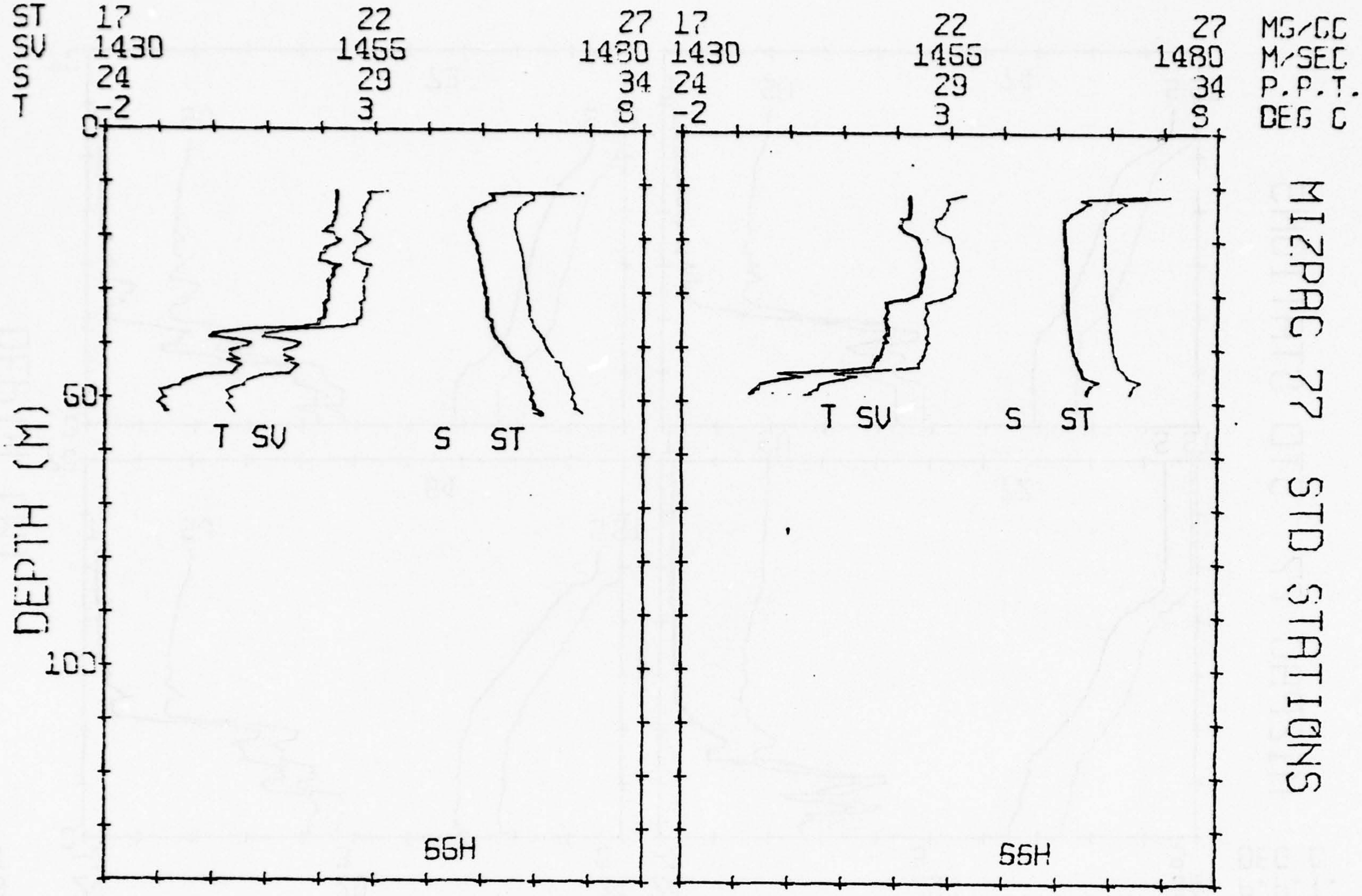


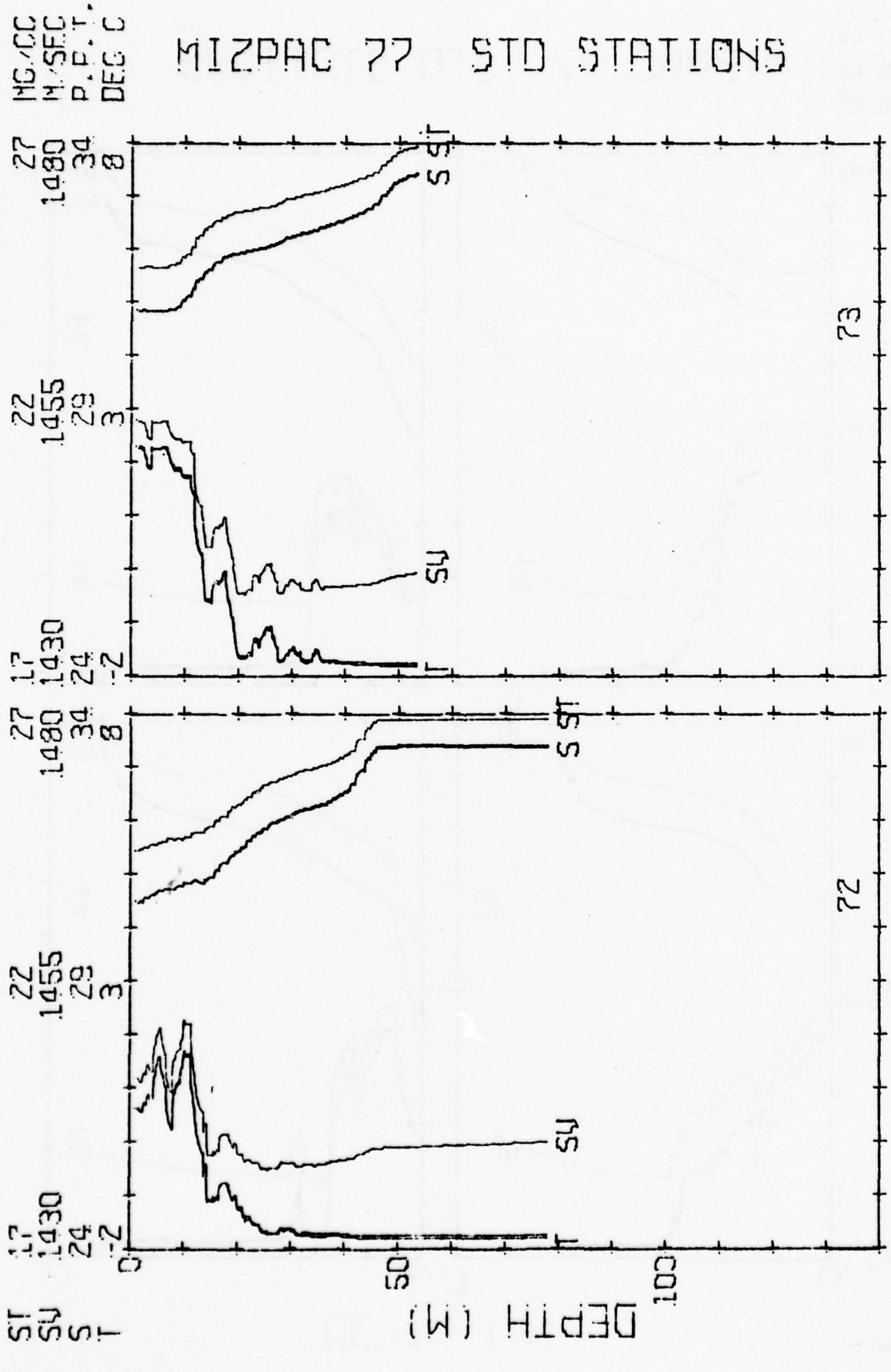
MIZPAC 77 STD STATIONS
ST SV S T
MG/CC M/SEC P.P.T. DEG C
17 1430 24 -2
22 1455 29 3
27 1480 34 8
DEPTH (M)
0
70
SV
S ST
57
56

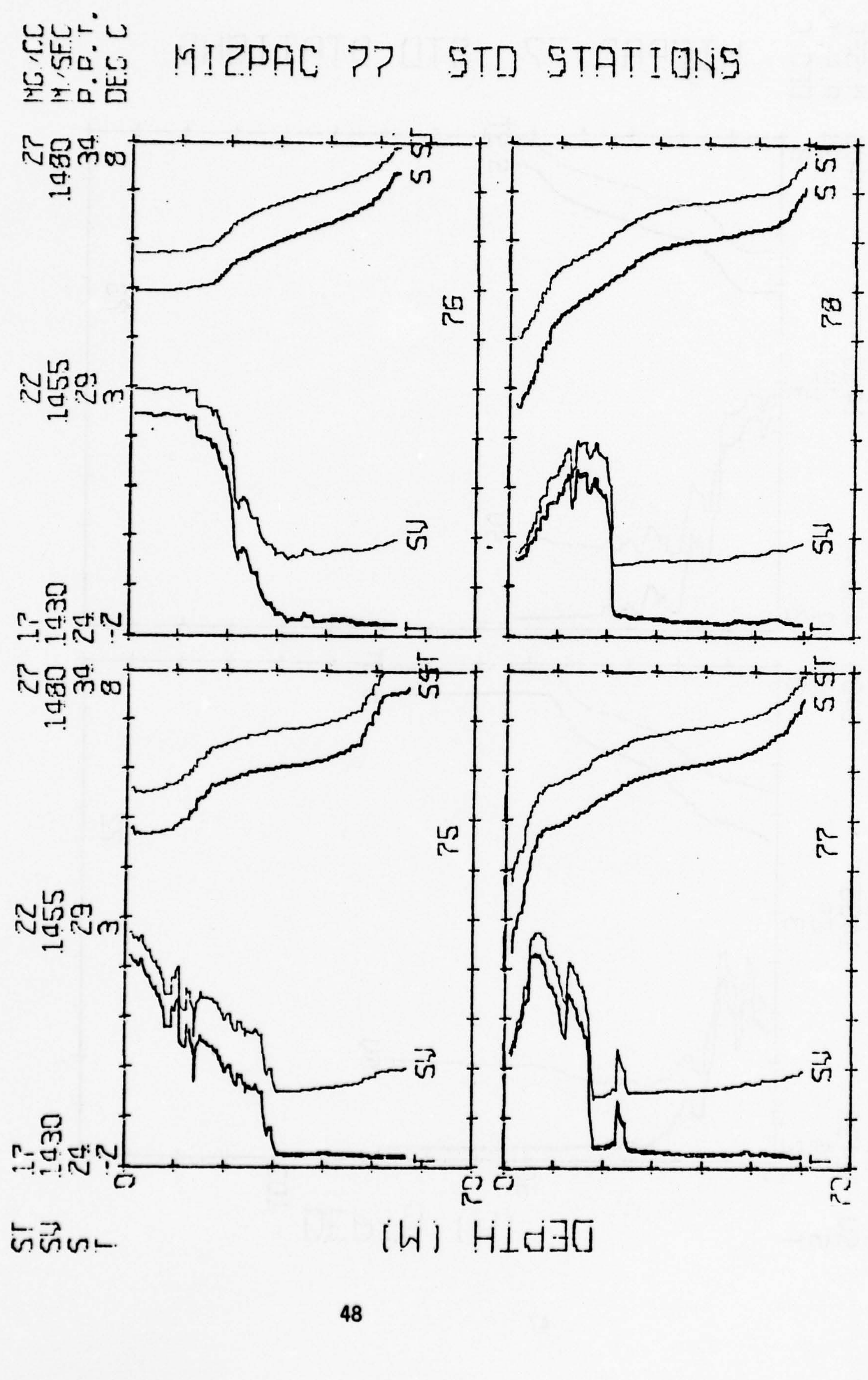


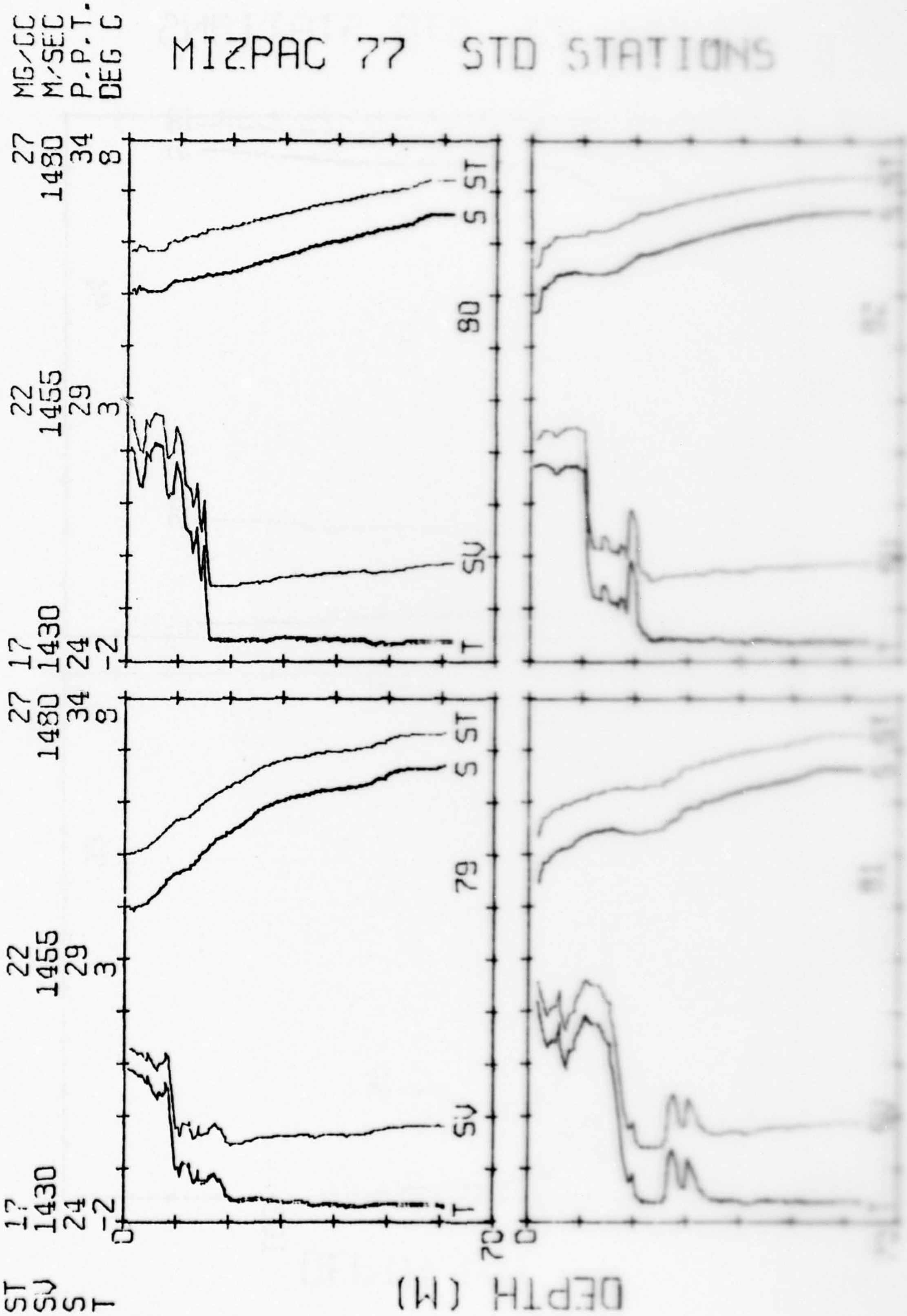
MIZPAC 77 STD STATIONS
ST SV S T
MG/CC M/SEC P.P.T. DEG C
17 1430 24 -2
22 1455 29 3
27 1480 34 8
60
61
62
63
SV
T
S
ST
DEPTH (M)
0
70


MIZPAC 77 STD STATIONS
MG/CC
M/SEC
P.P.T.
DEG C
ST
SV
S
T
DEPTH (M)
72
74
64
73
S ST
SV
0
70


MIZPAC 77 STD STATIONS
ST
SV
S
T
17
1430
24
-2
22
1455
29
3
27
1480
34
8
MG/CC
M/SEC
P.P.T.
DEG C
DEPTH (M)
0
50
100
T SV
S ST
SSH


MIZPAC 77 STD STATIONS
MG/CC
M/SEC
P.P.T.
DEG C
27 1480 34 8
22 1455 29 3
17 1430 24 -2
S ST
SV
T
73
72
0
50
100
ST
SV
S
T
DEPTH (M)


MIZPAC 77 STD STATIONS
ST
SV
S
T
MG/CC
M/SEC
P.P.T.
DEG C
DEPTH (M)
75
76
77
78
SST
SV
T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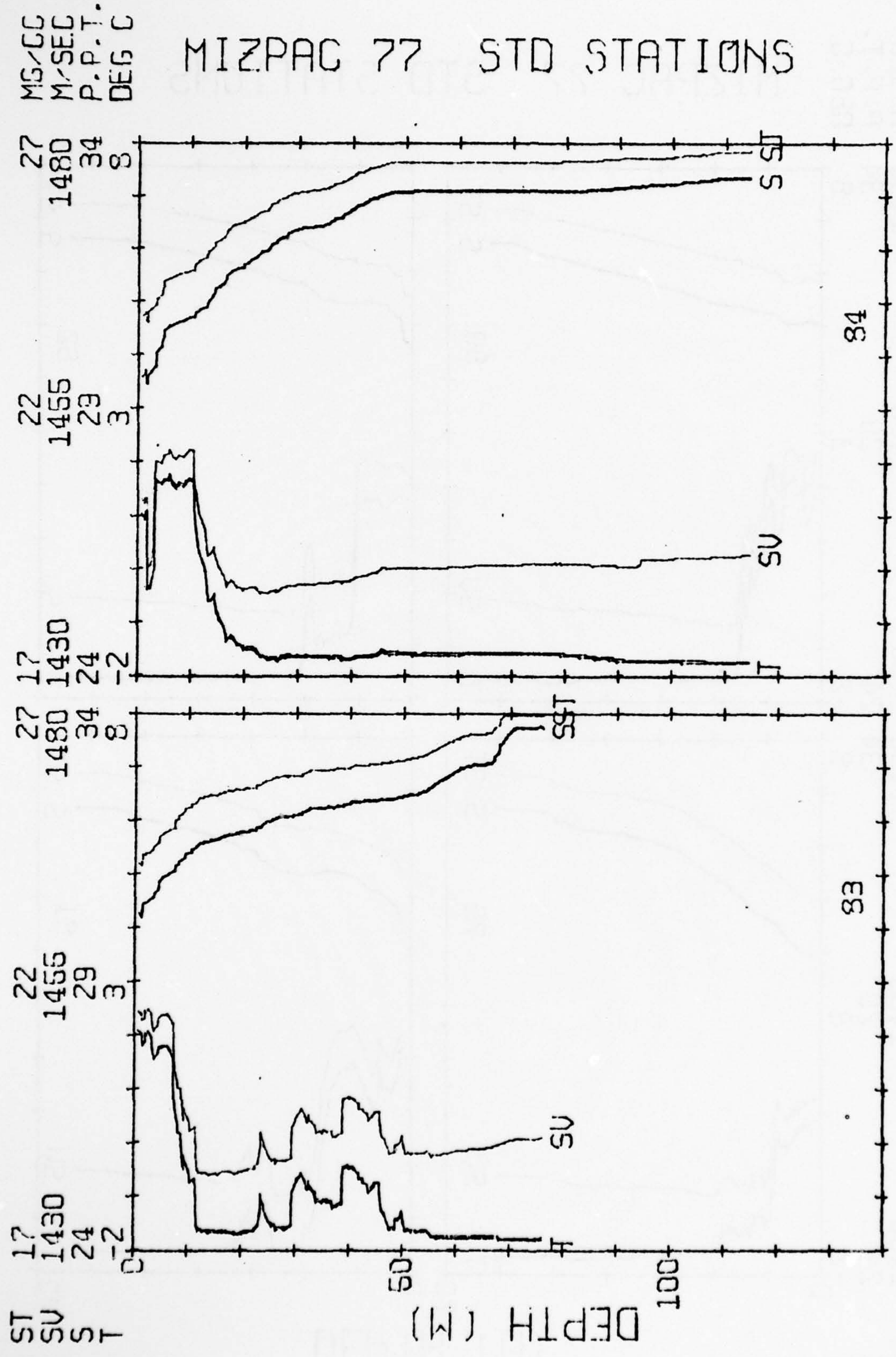
MG/CC
M/SEC
P.P.T.
DEG C
DEPTH (M)
ST
SV
S
T
80
79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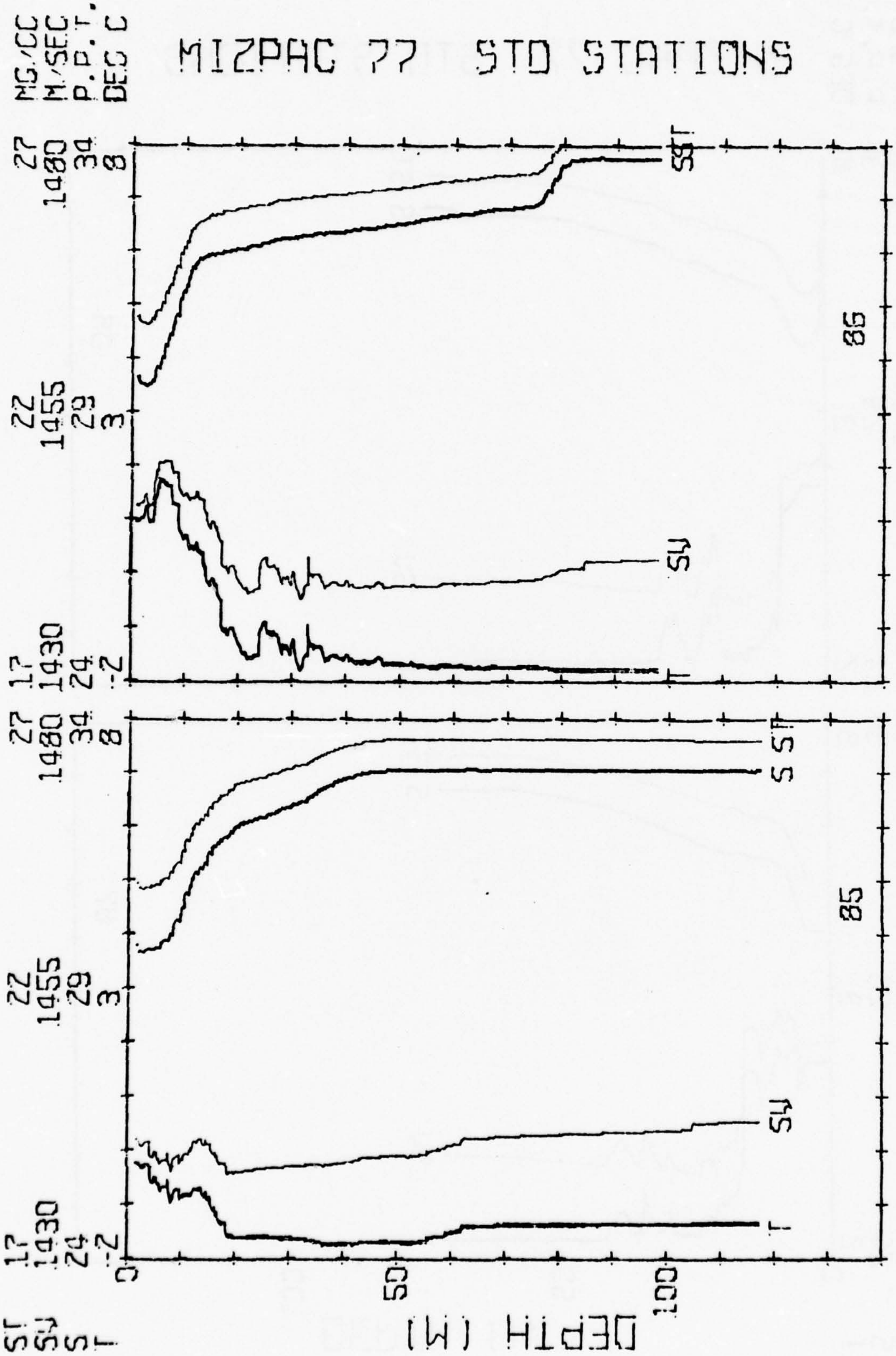
MS/CC
M/SEC
P.P.T.
DEG C
27 1480 34 8
22 1455 29 3
17 1430 24 -2
ST
SV
S
T
SV
34
33
0
50
100
DEPTH (M)



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MG/CC
M/SEC
P.P.T.
DEG C
ST
SV
S
T
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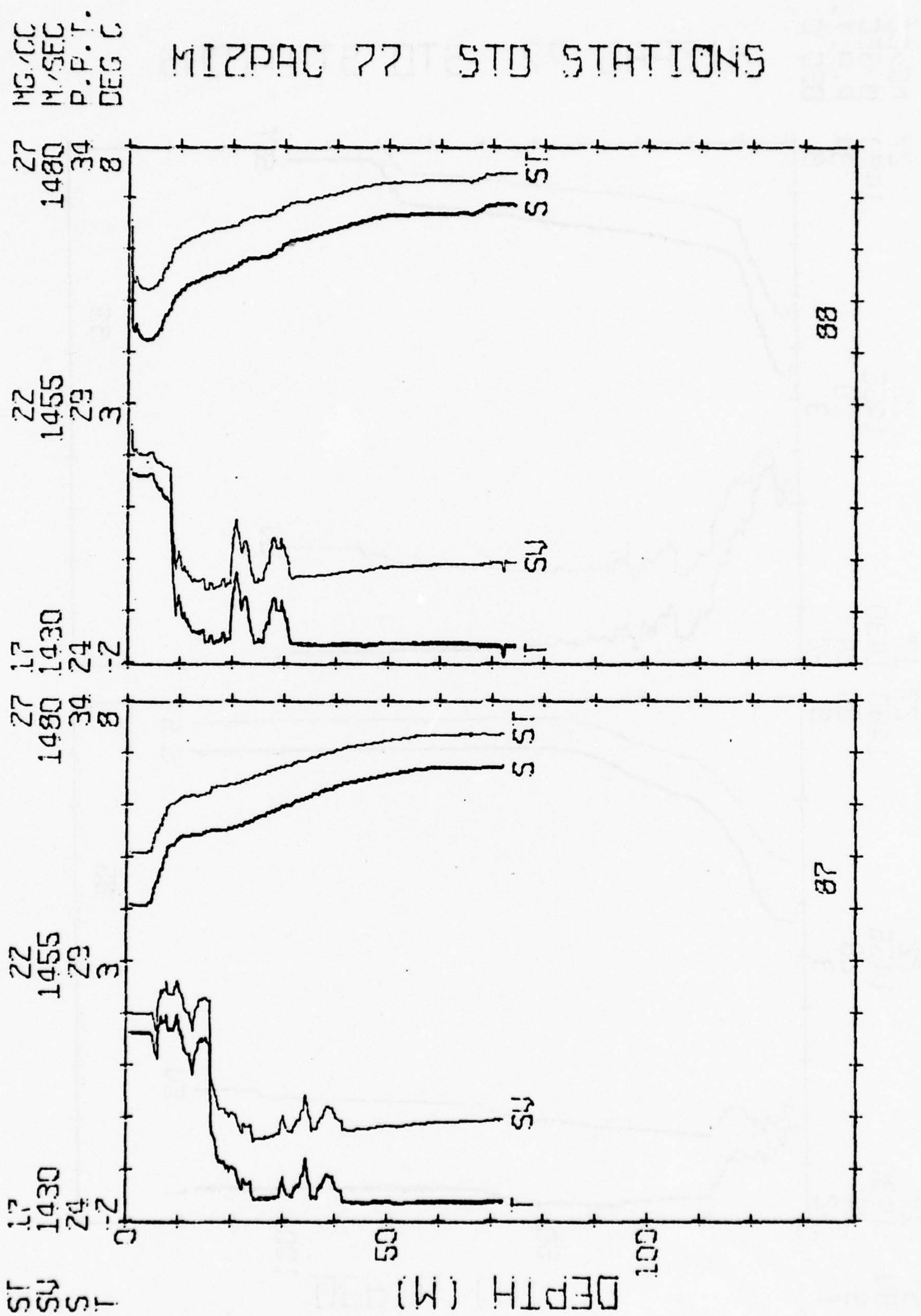
DEPTH (M)
0
50
100



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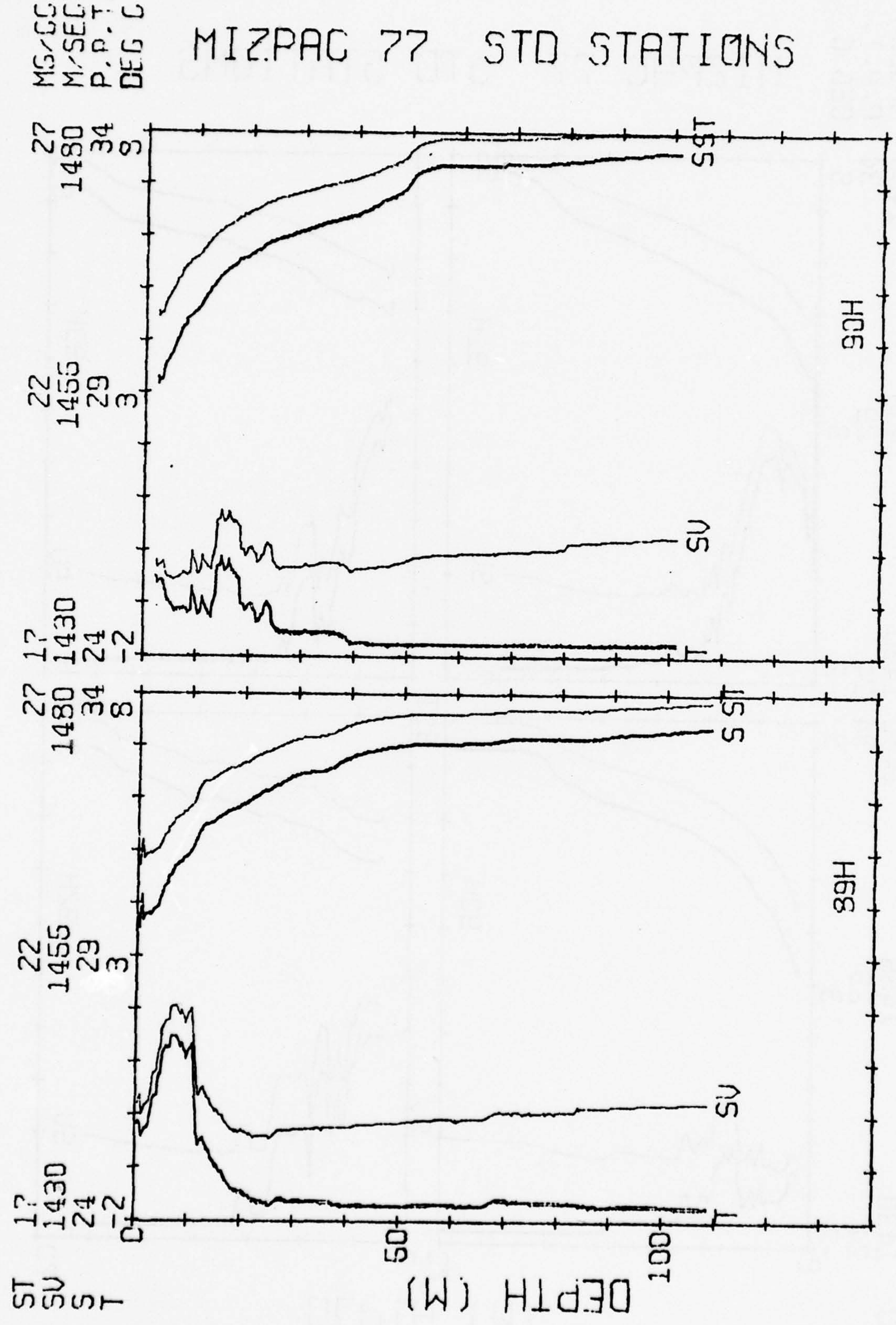
ST SV S T
MG/CC M/SEC P.P.T. DEG C
DEPTH (M)
88
87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MS/CC
M/SEC
P.P.T.
DEG C
ST
SV
S
T
DEPTH (M)
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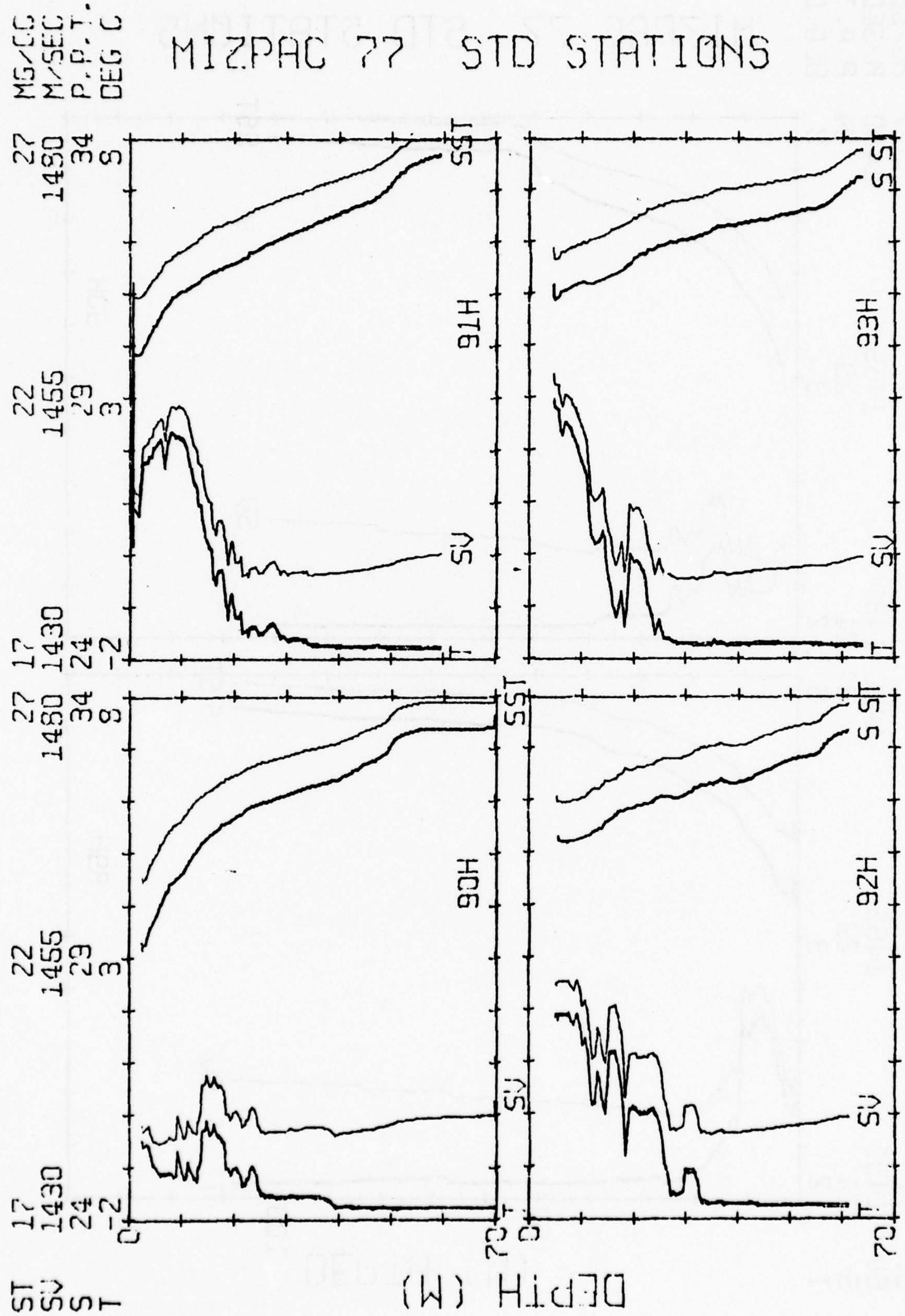
50
100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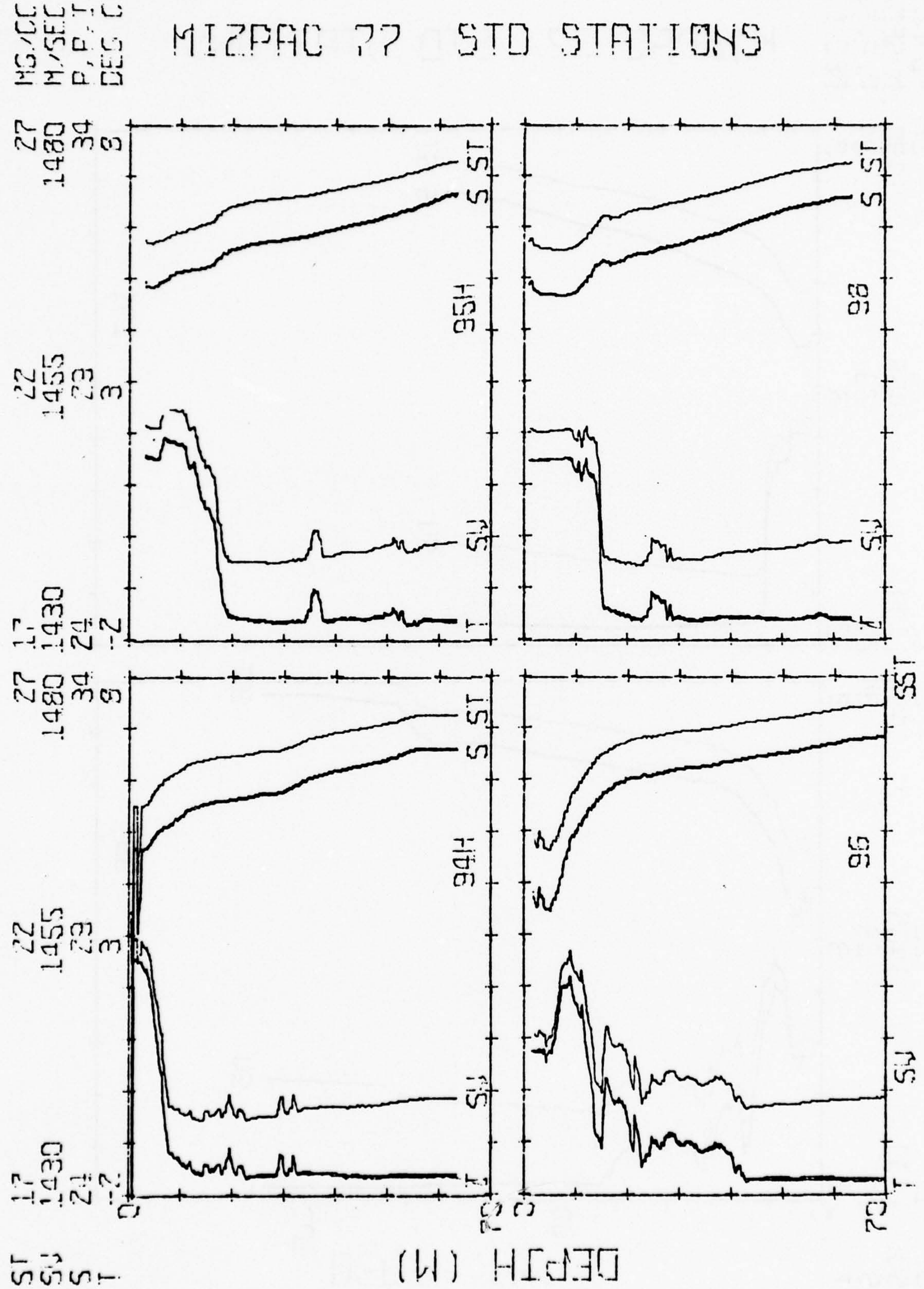
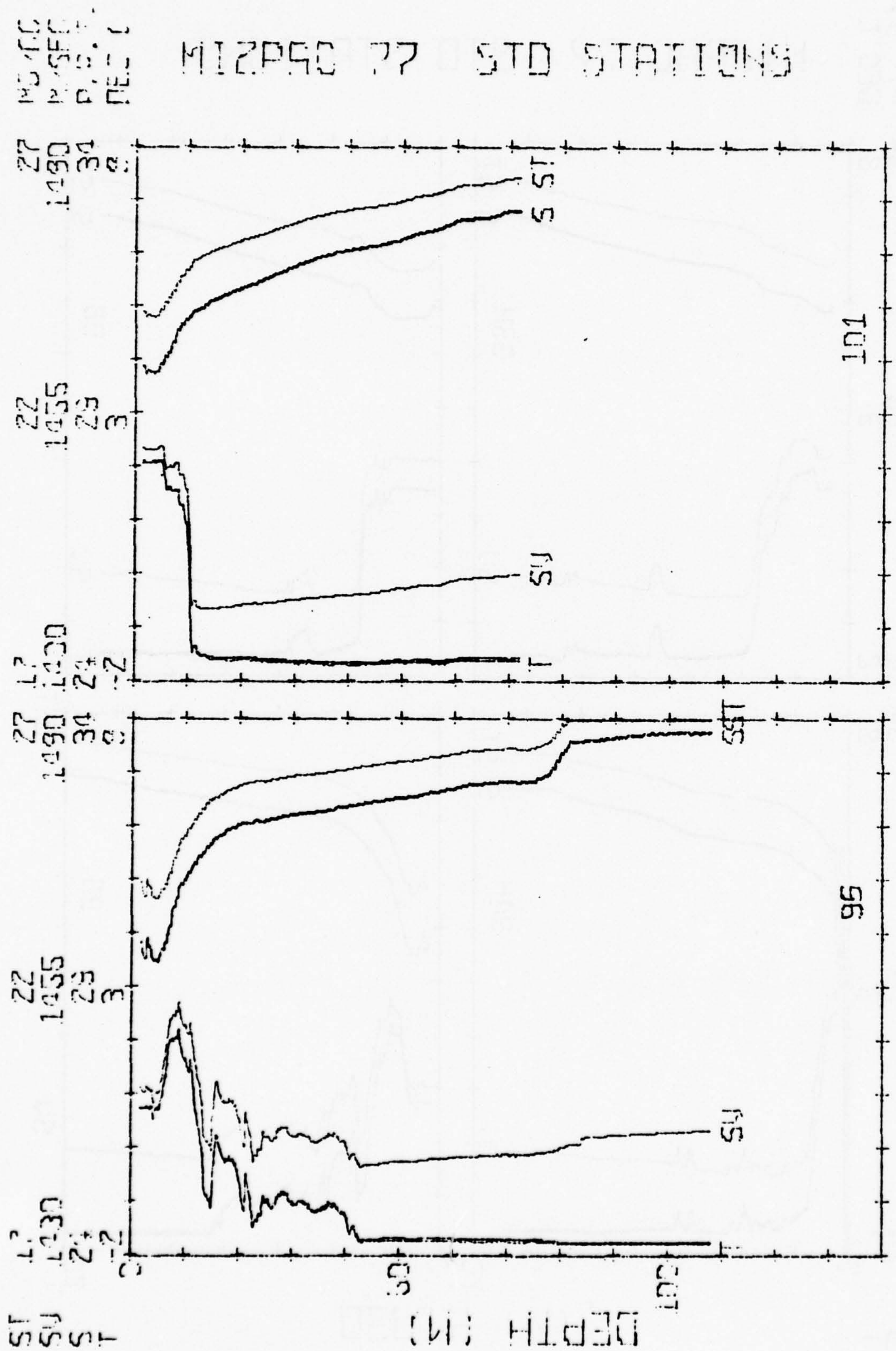
MG/CC
M/SEC
P.P.T.
DEG C
ST
SV
S
T
91H
93H
90H
92H
DEPTH (M)

MIZPAC 77 STD STATIONS

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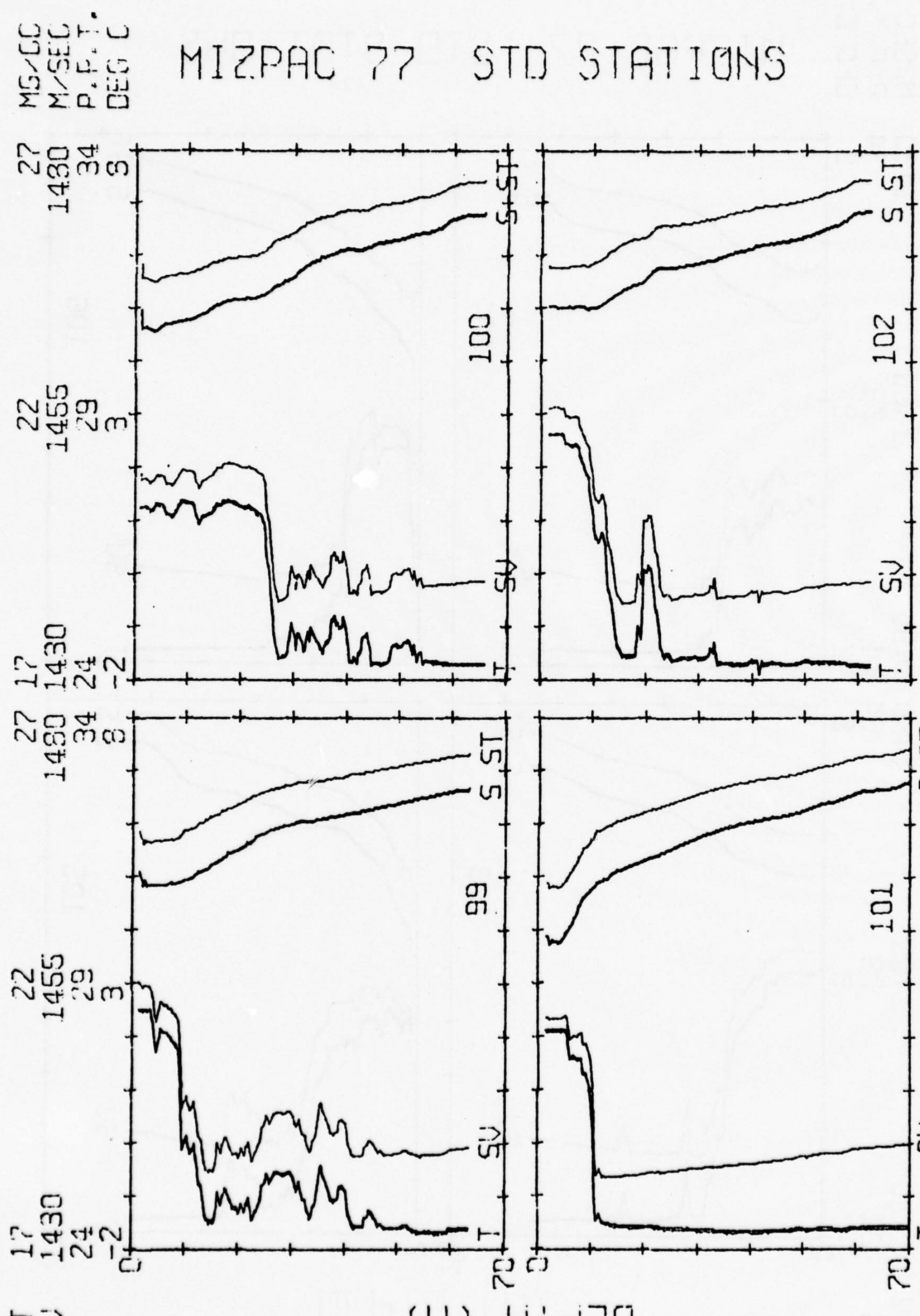
DEPTH (M)
0
50
100
101
96
S ST
S
SU
T
SST
ST
SU
S
T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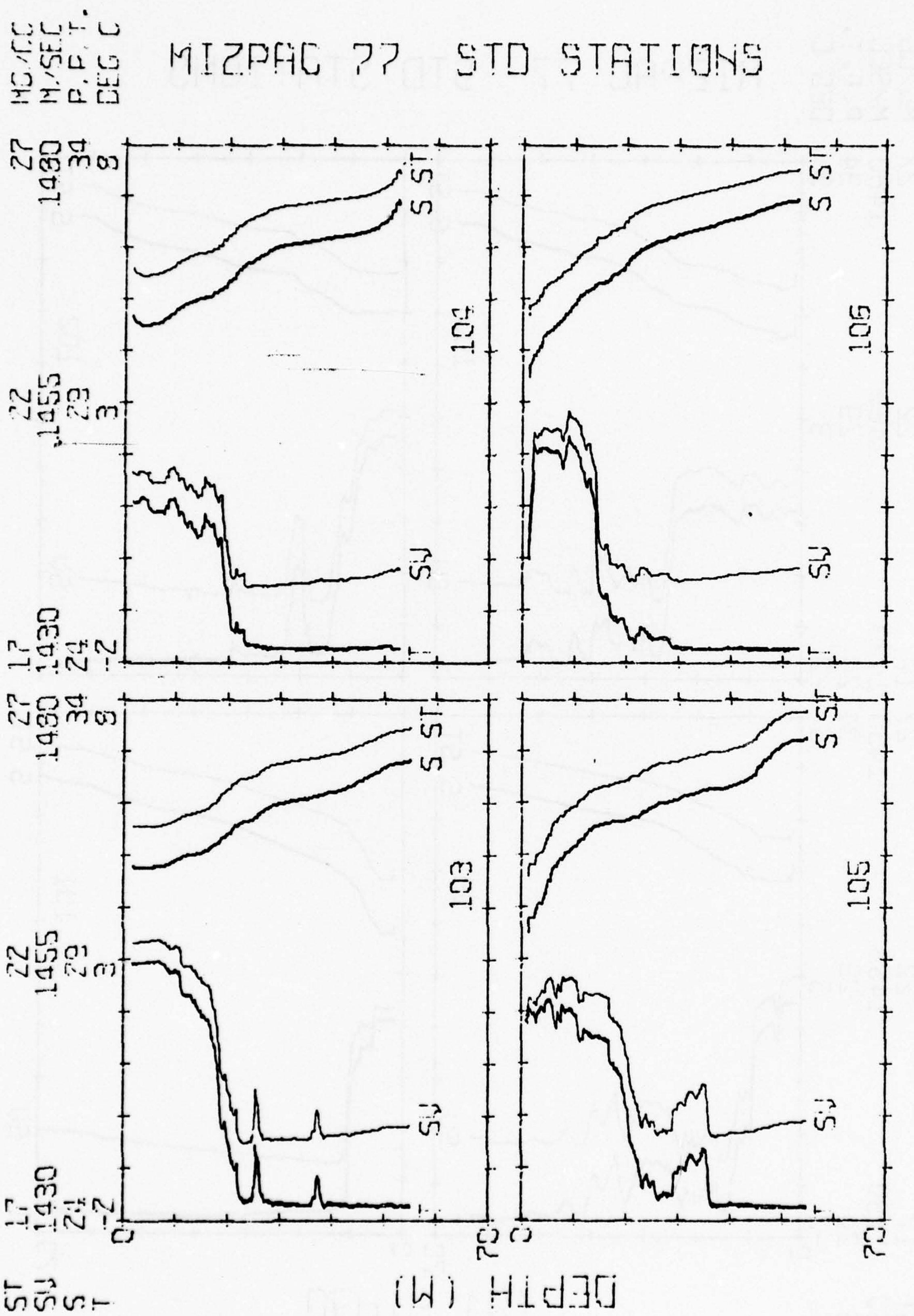
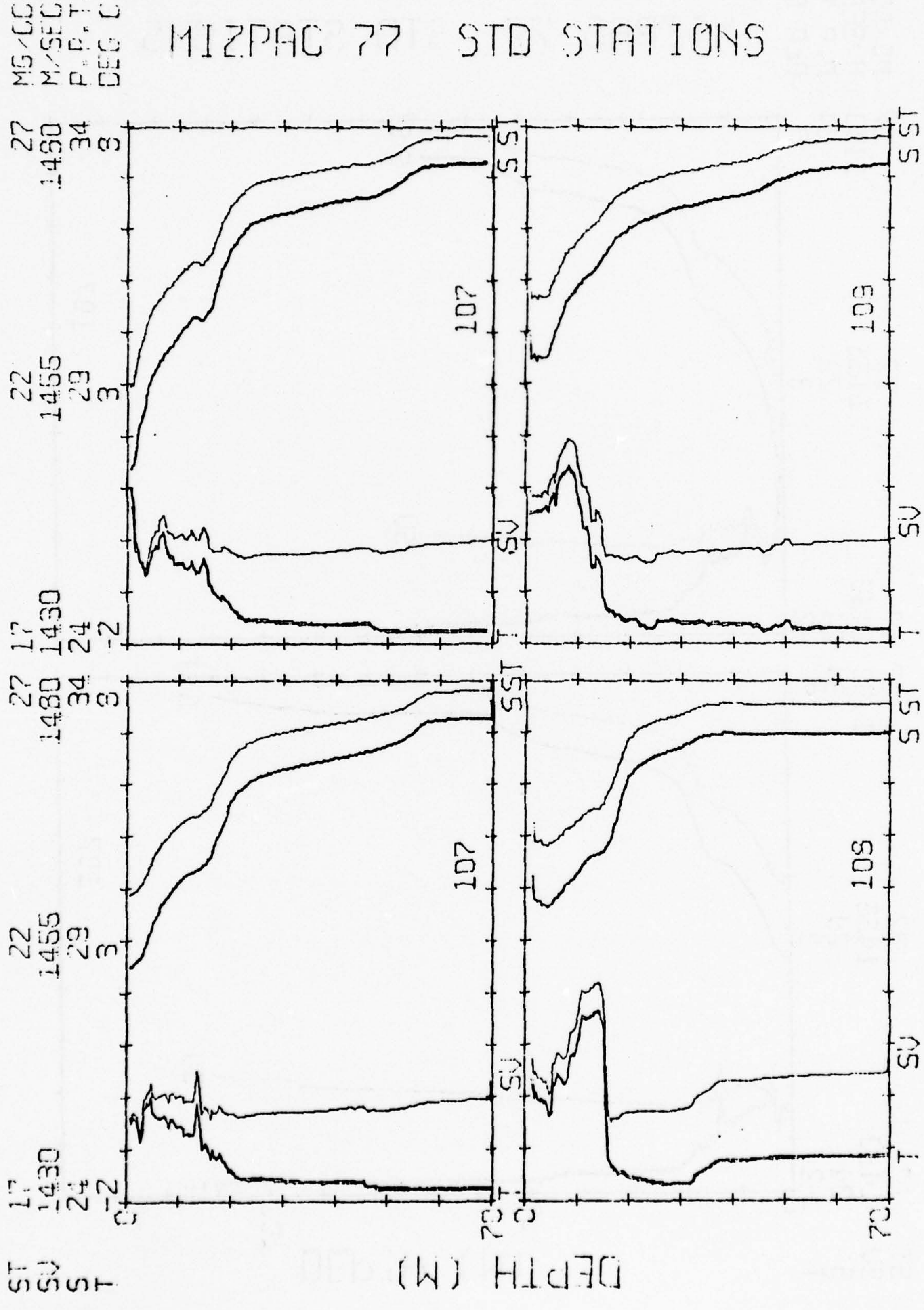
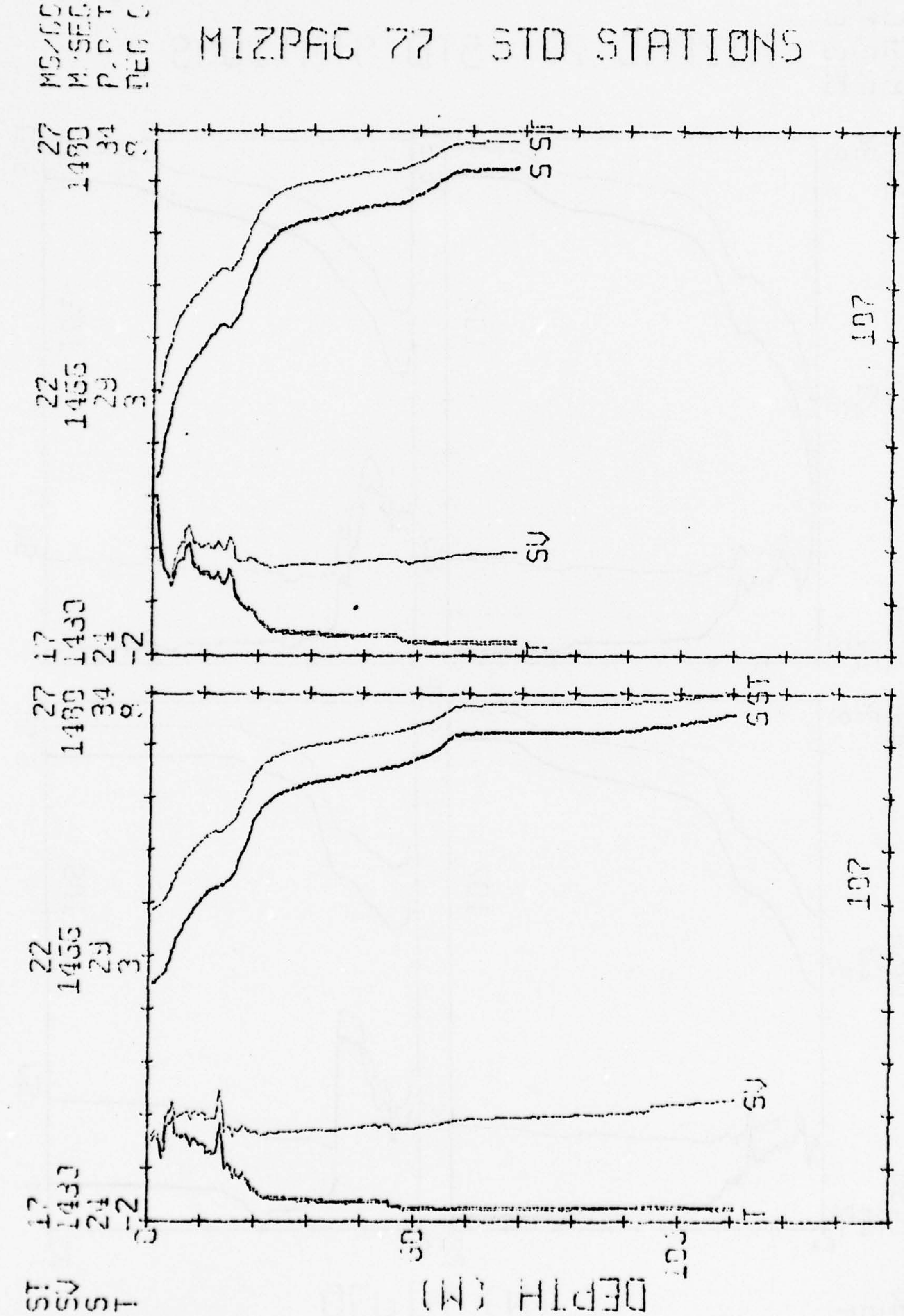
MS/CC
M/SEC
P.P.T.
DEG C
DEPTH (M)
100
102
99
101
ST SV S T


MIZPAC 77 STD STATIONS
MC/CC
M/SEC
P.P.T.
DEG C
ST
SV
S
T
DEPTH (M)
103
104
105
106


MIZPAC 77 STD STATIONS
MG/CC
M/SEC
P.P.T.
DEG C
ST
SV
S
T
27
1430
34
3
22
1455
29
3
17
1430
24
-2
107
108
S
ST
SV
T
0
70
DEPTH (M)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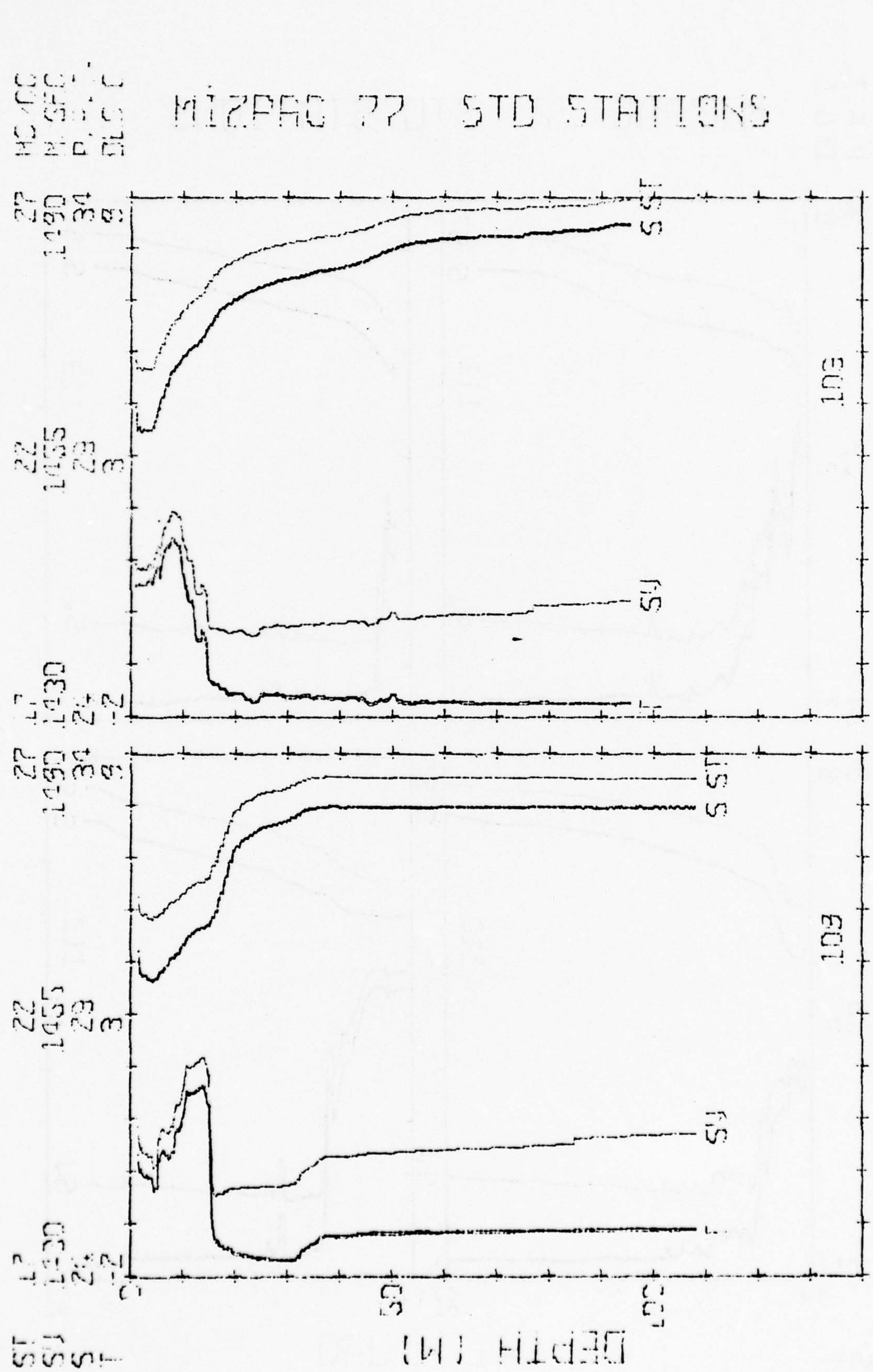
DEPTH (M)
197
S ST
SV
T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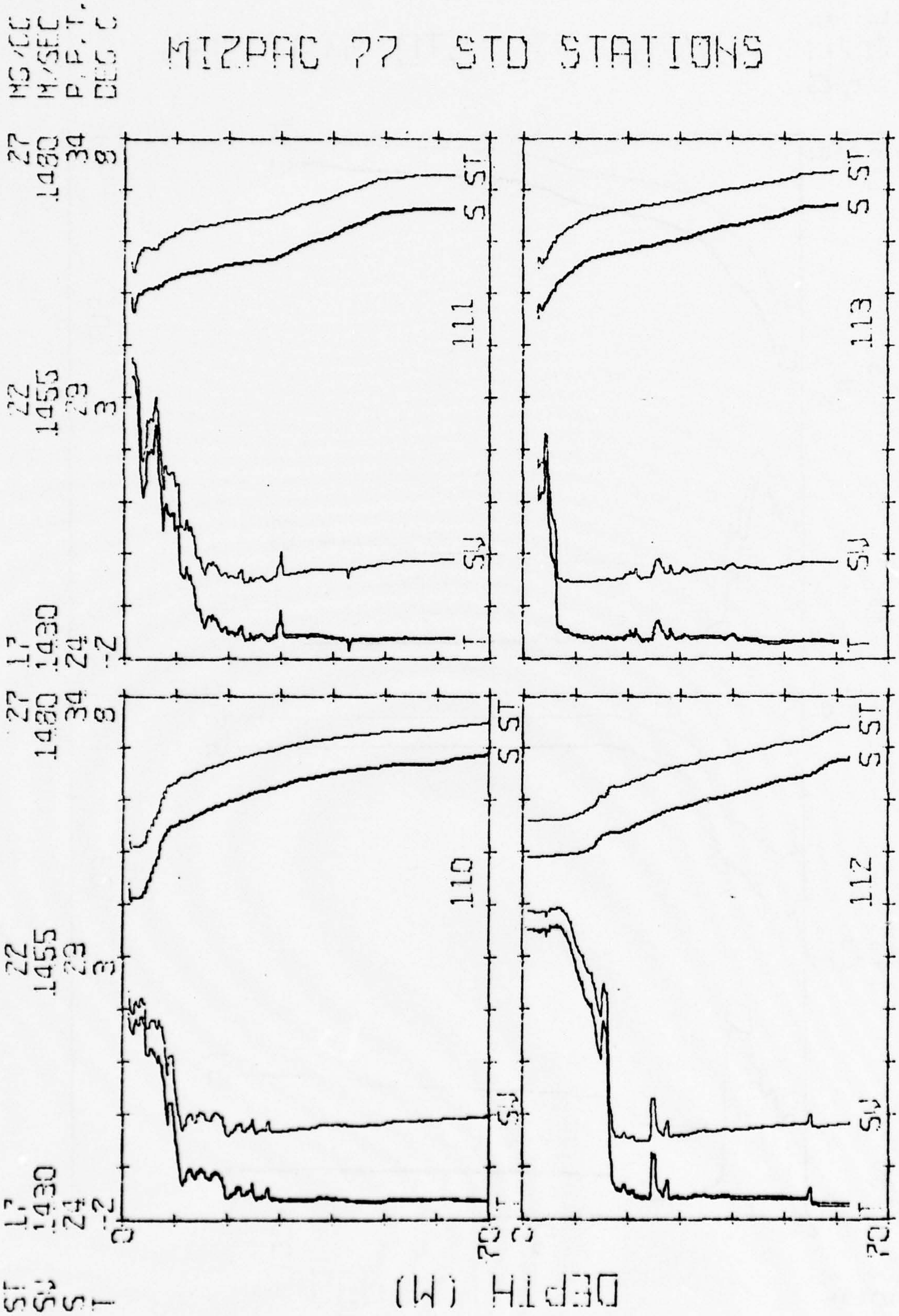
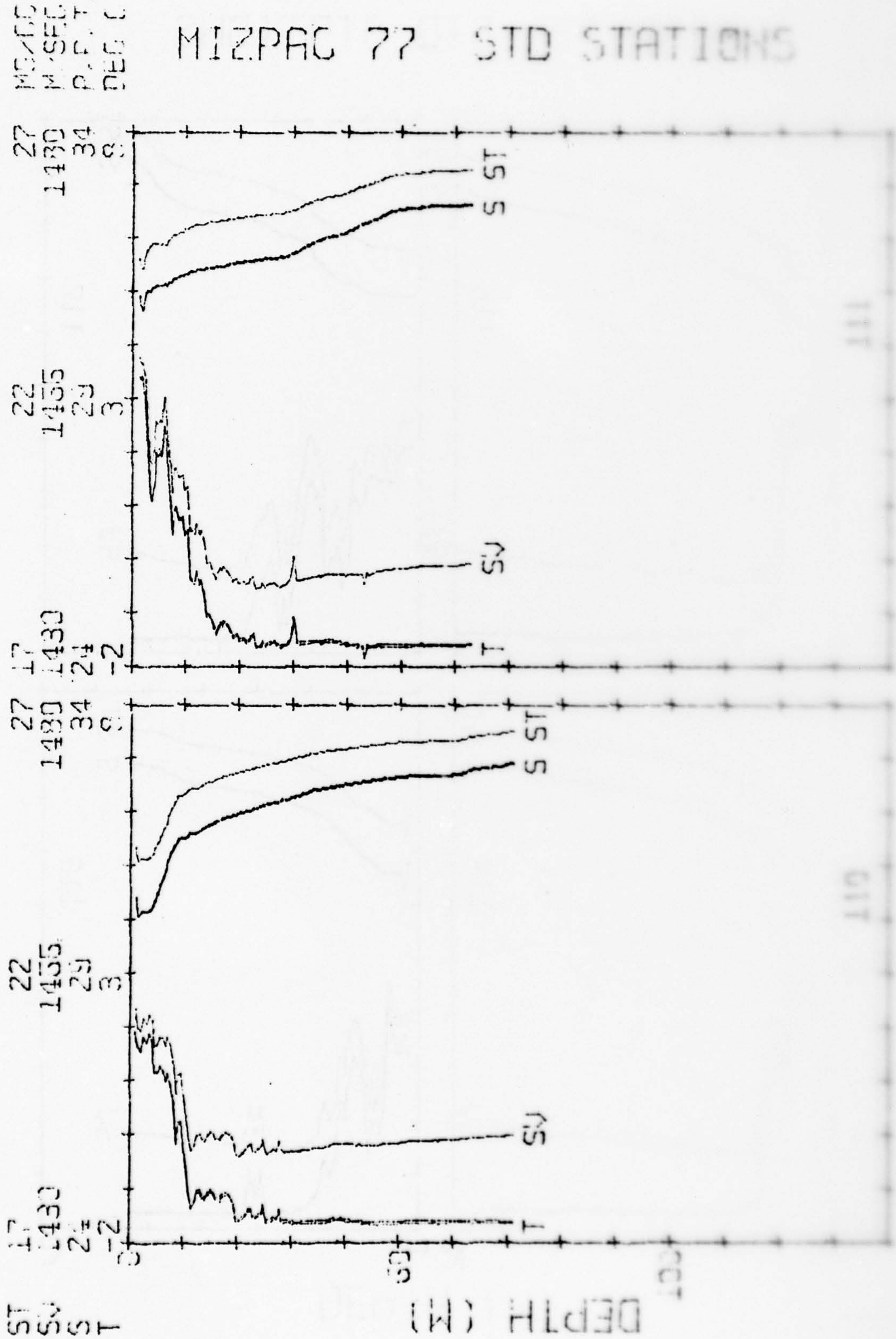
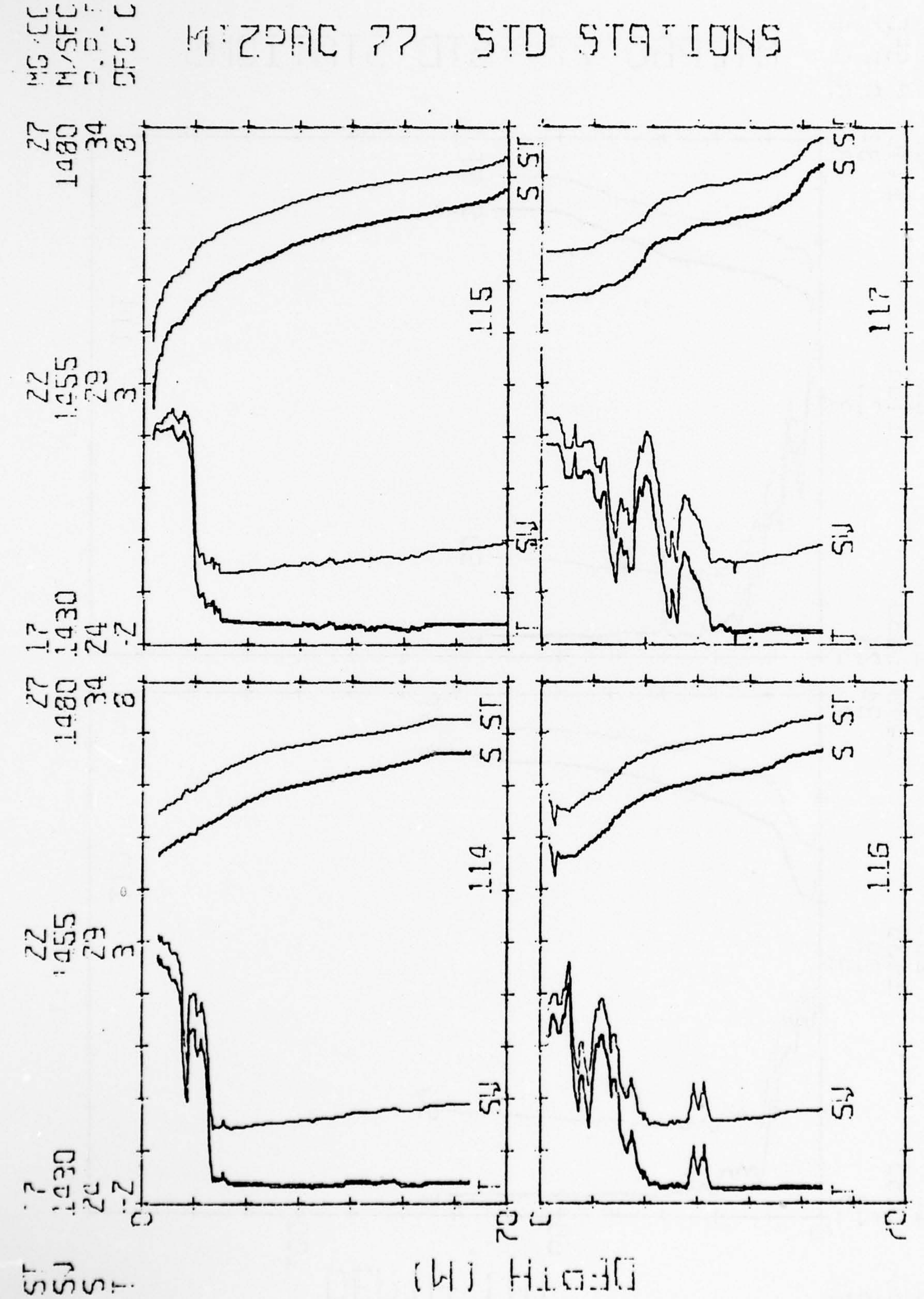
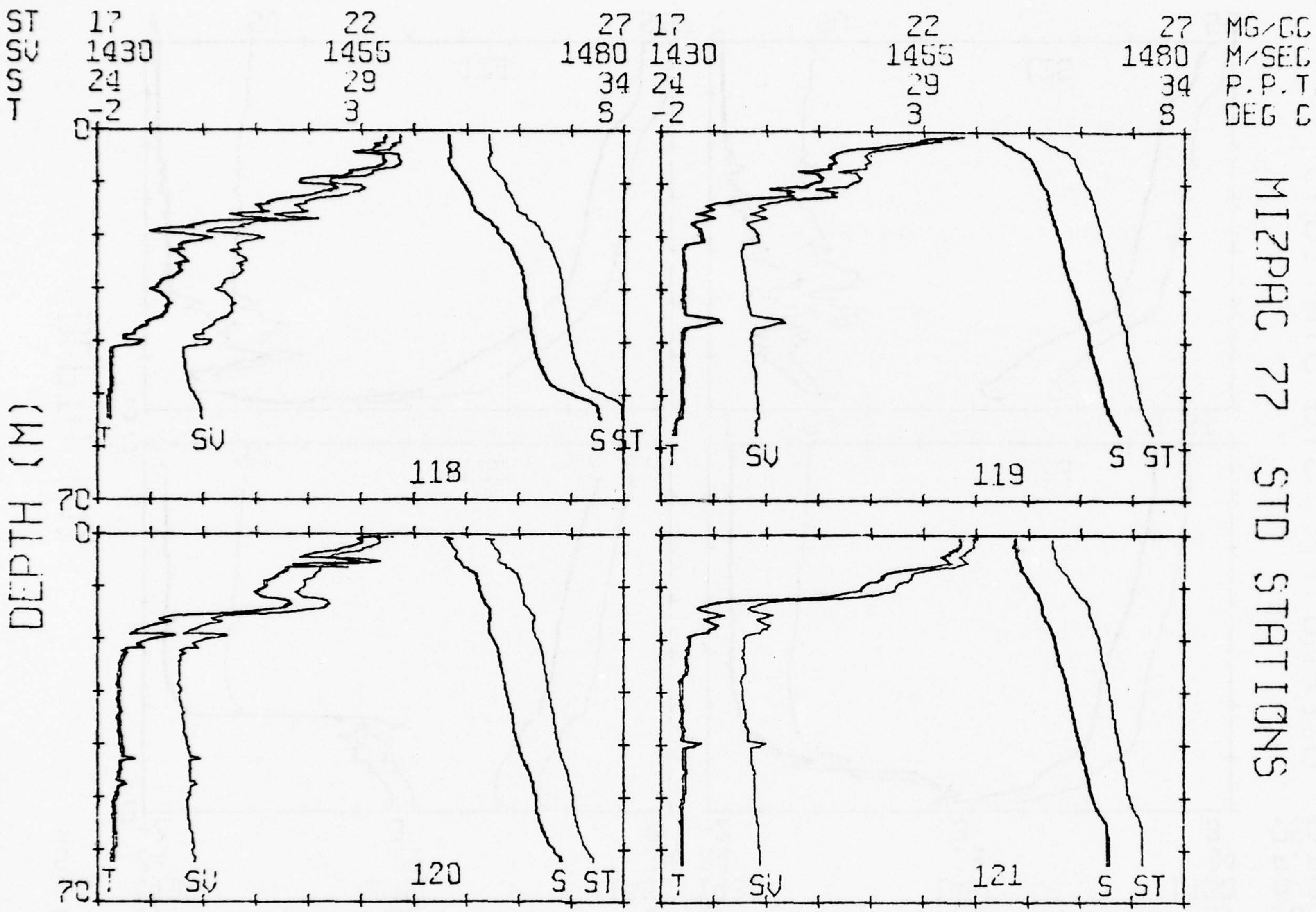
DEPTH (M)
103
103

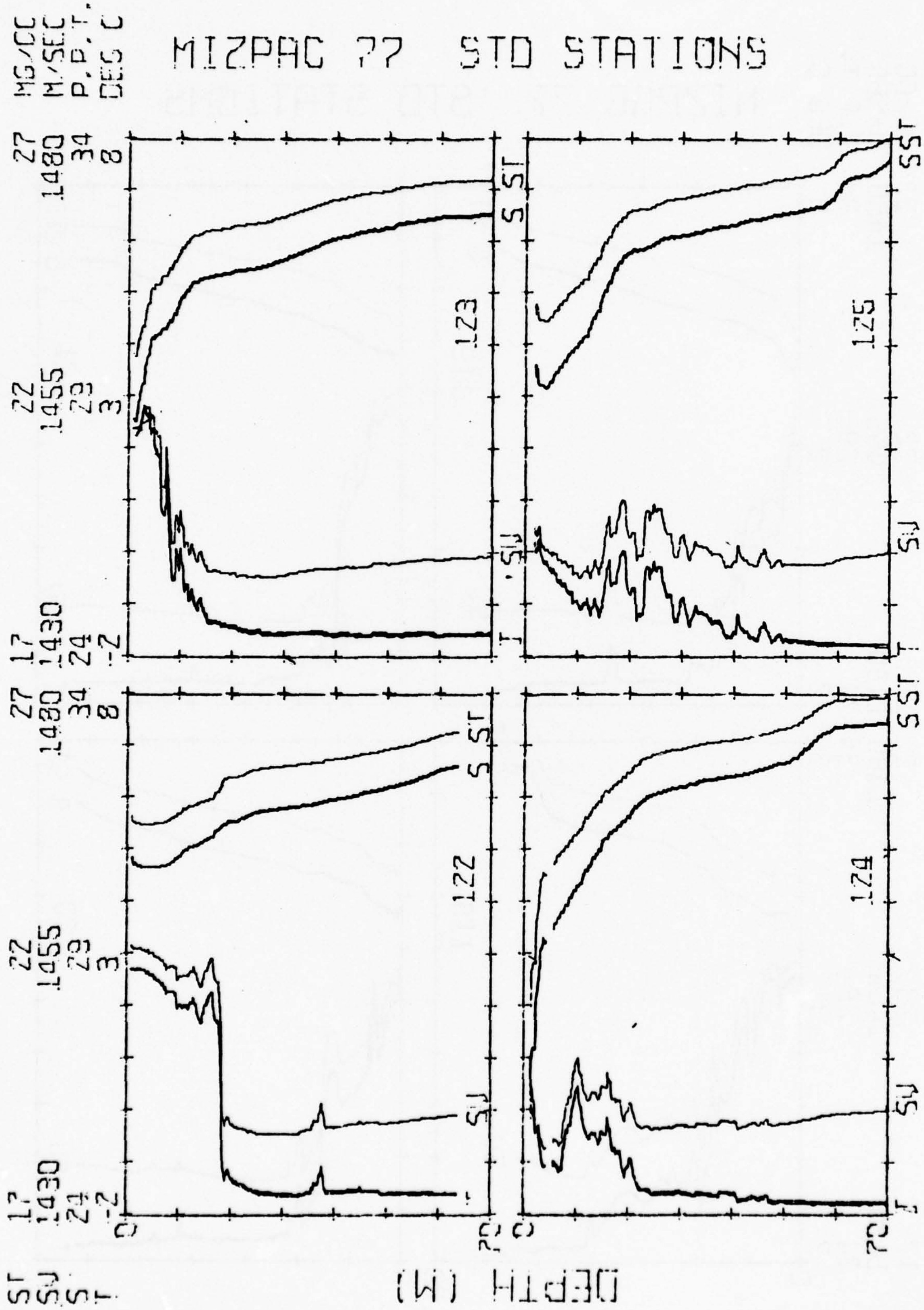


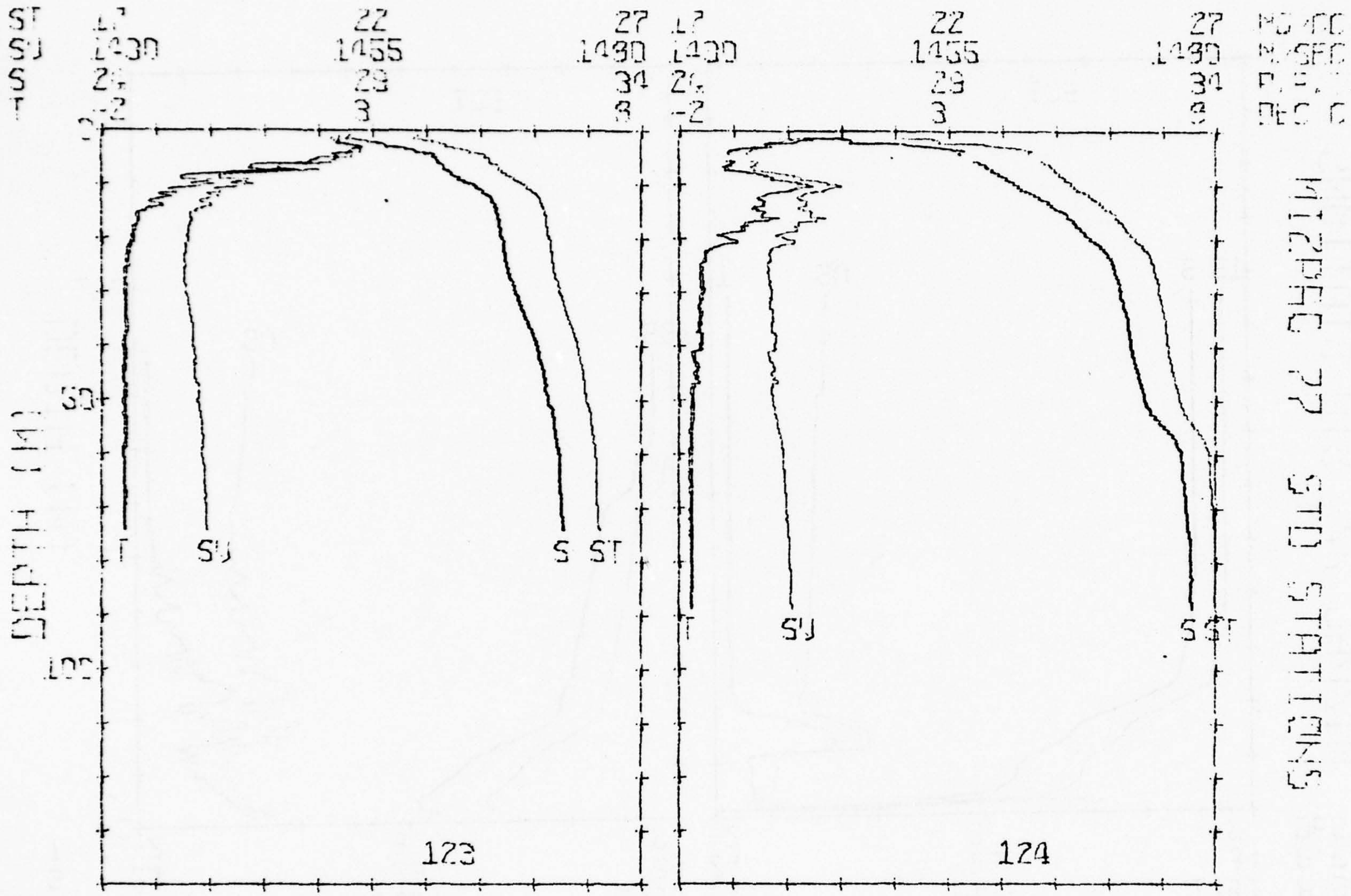
MIZPAC 77 STD STATIONS
111
113
110
112
DEPTH (M)


MIZPAC 77 STD STATIONS
DEPTH (M)
0
50
100
S ST
S
SV
T
27
1480
34
22
1455
29
3
17
1430
24
2


MIZPAC 77 STD STATIONS
115
117
114
116
DEPTH (M)


MIZPAC 77 STD STATIONS
ST SV S T
17 1430 24 -2
22 1455 29 3
27 1480 34 8
MG/CC
M/SEC
P.P.T.
DEG C
DEPTH (M)
0
70
118
119
120
121
T
SV
S
ST


MIZPAC 77 STD STATIONS
MG/CC
M/SEC
P.P.T.
DEG C
27
1480
34
8
22
1455
29
3
17
1430
24
-2
123
125
122
124
S ST
SV
T
ST
SV
S
T
DEPTH (M)
0
20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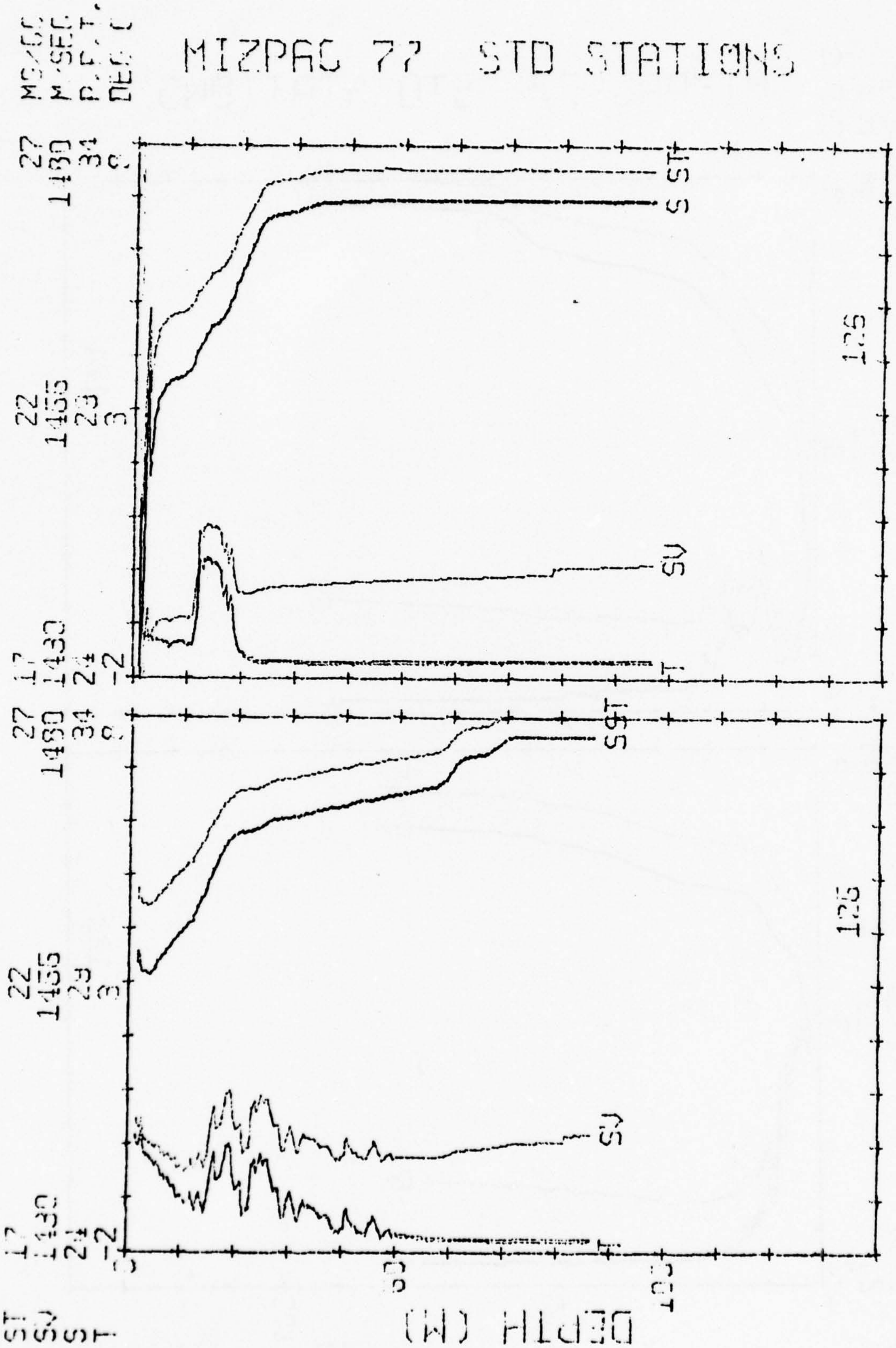
ST
SV
S
T
22
1430
1455
1490
24
29
34
-2
3
8
27
0
50
100
DEPTH (M)
T
SV
S
ST
123
124



MIZPAC 77 STD STATIONS
DEPTH (M)
0
50
100
125
SST
S
SV
T
17
1430
24
-2
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1455
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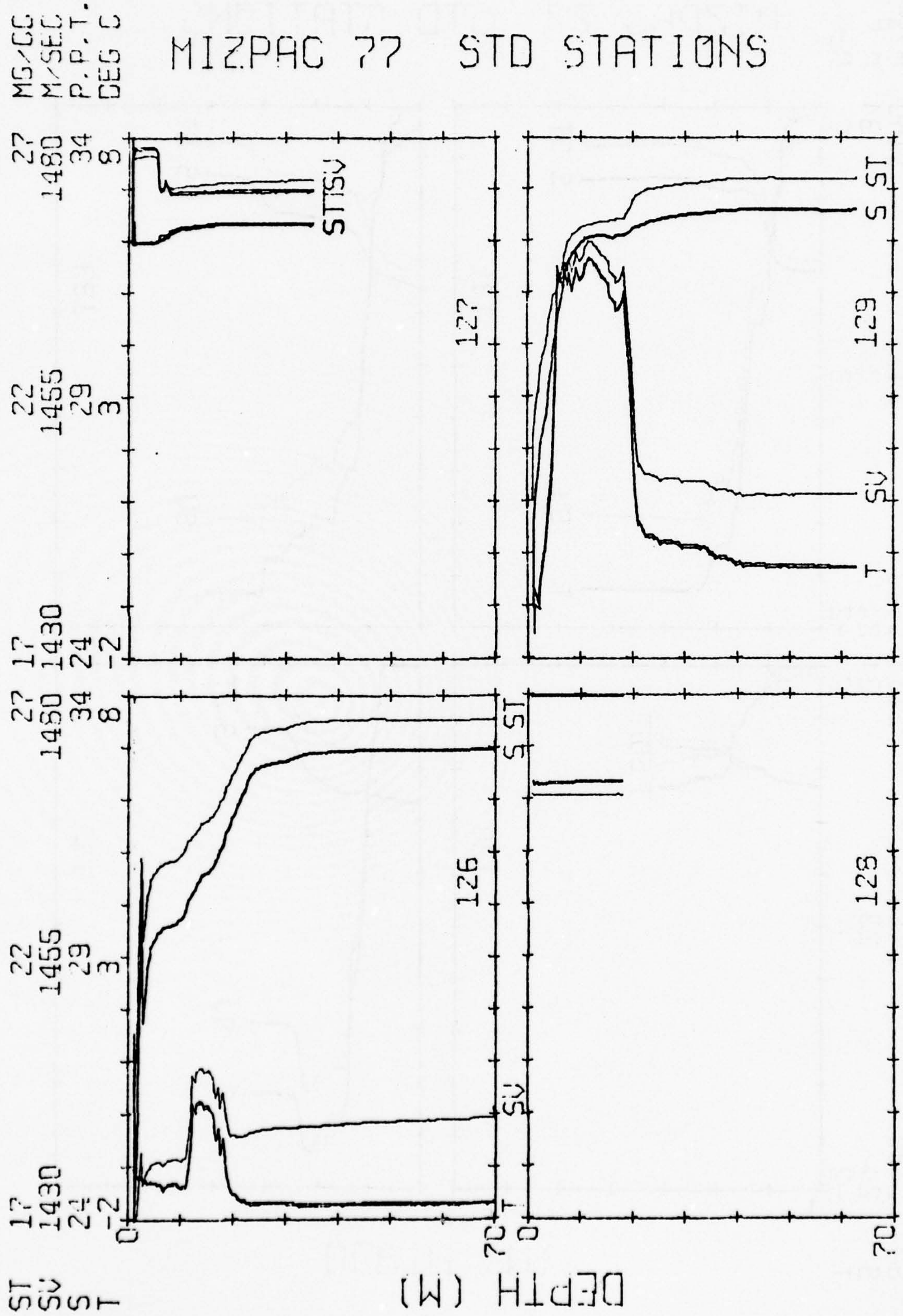
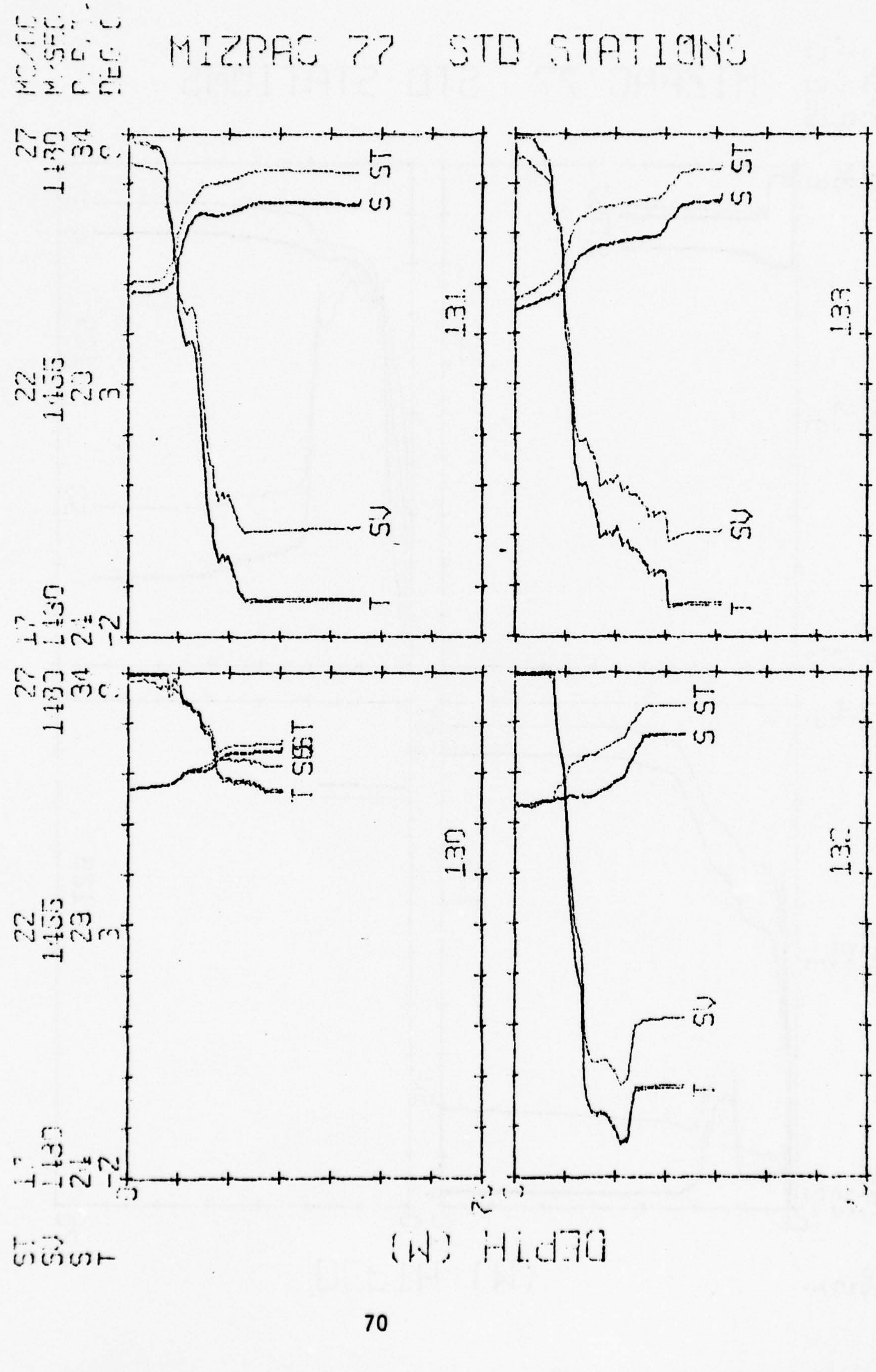
3
27
1480
34
8



MIZPAC 77 STD STATIONS
MG/CC
M/SEC
P.P.T.
DEG C
ST
SV
S
T
DEPTH (M)
126
127
128
129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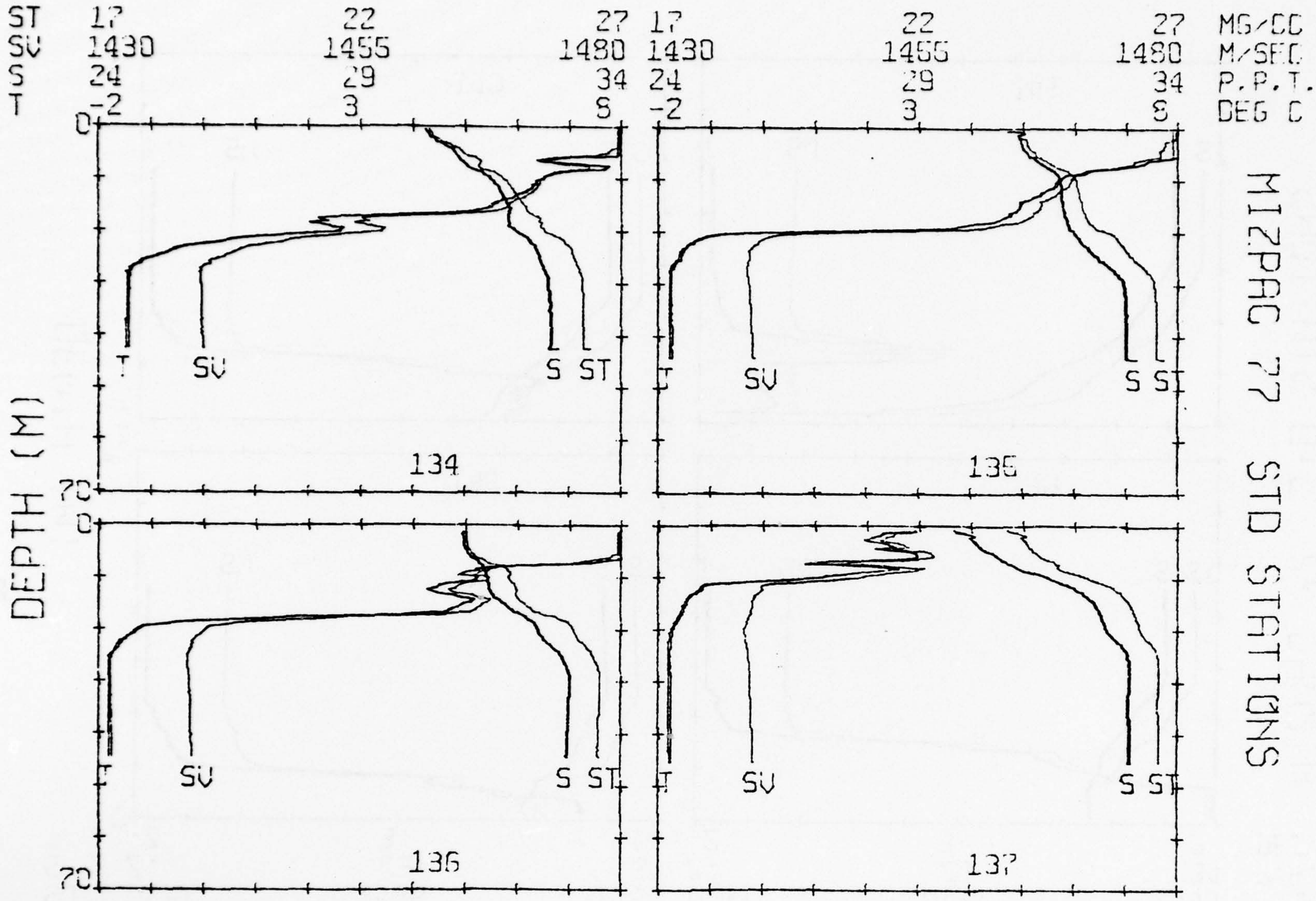
131
133
130
132
S ST
S
SV
T
DEPTH (M)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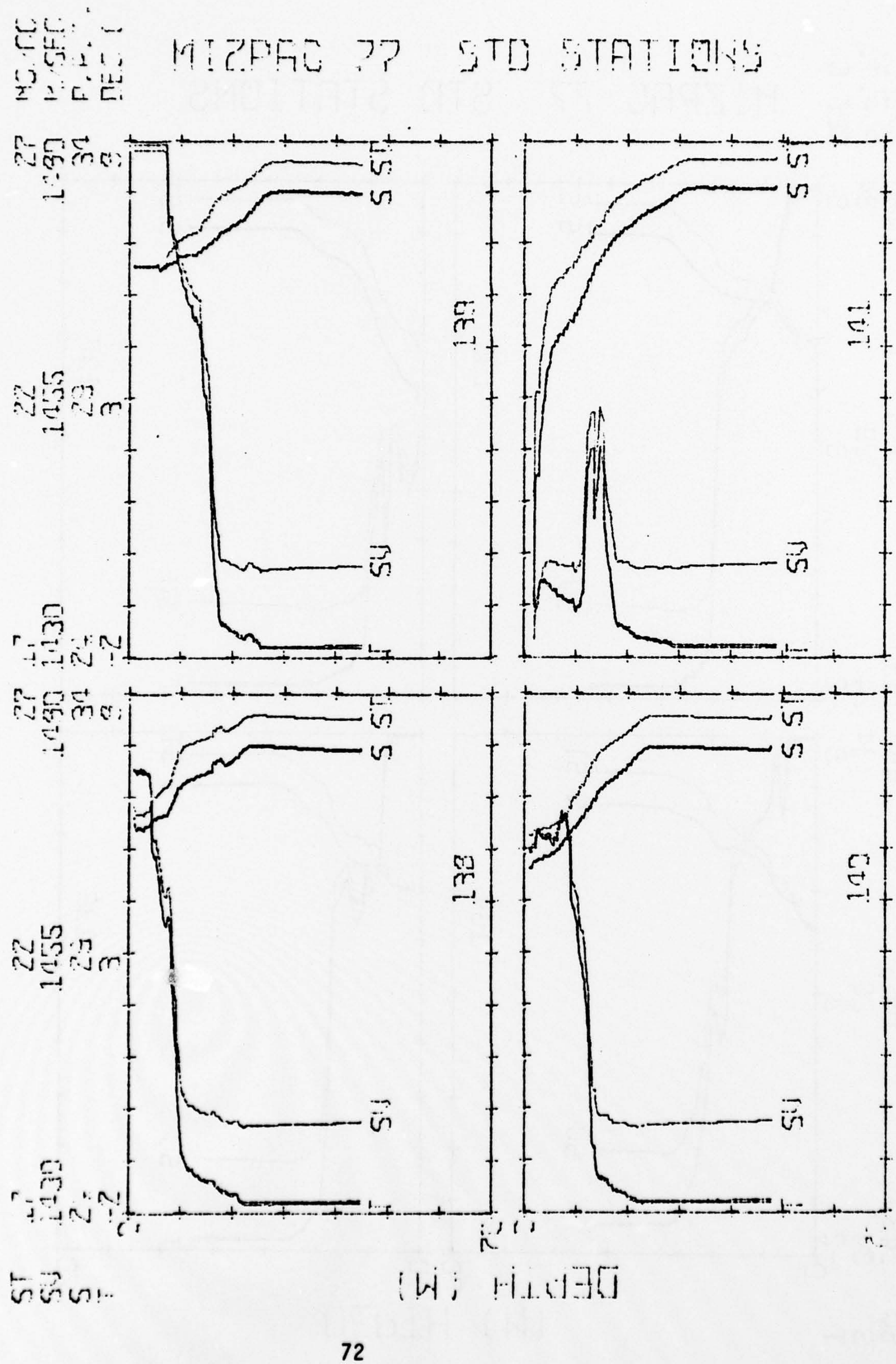
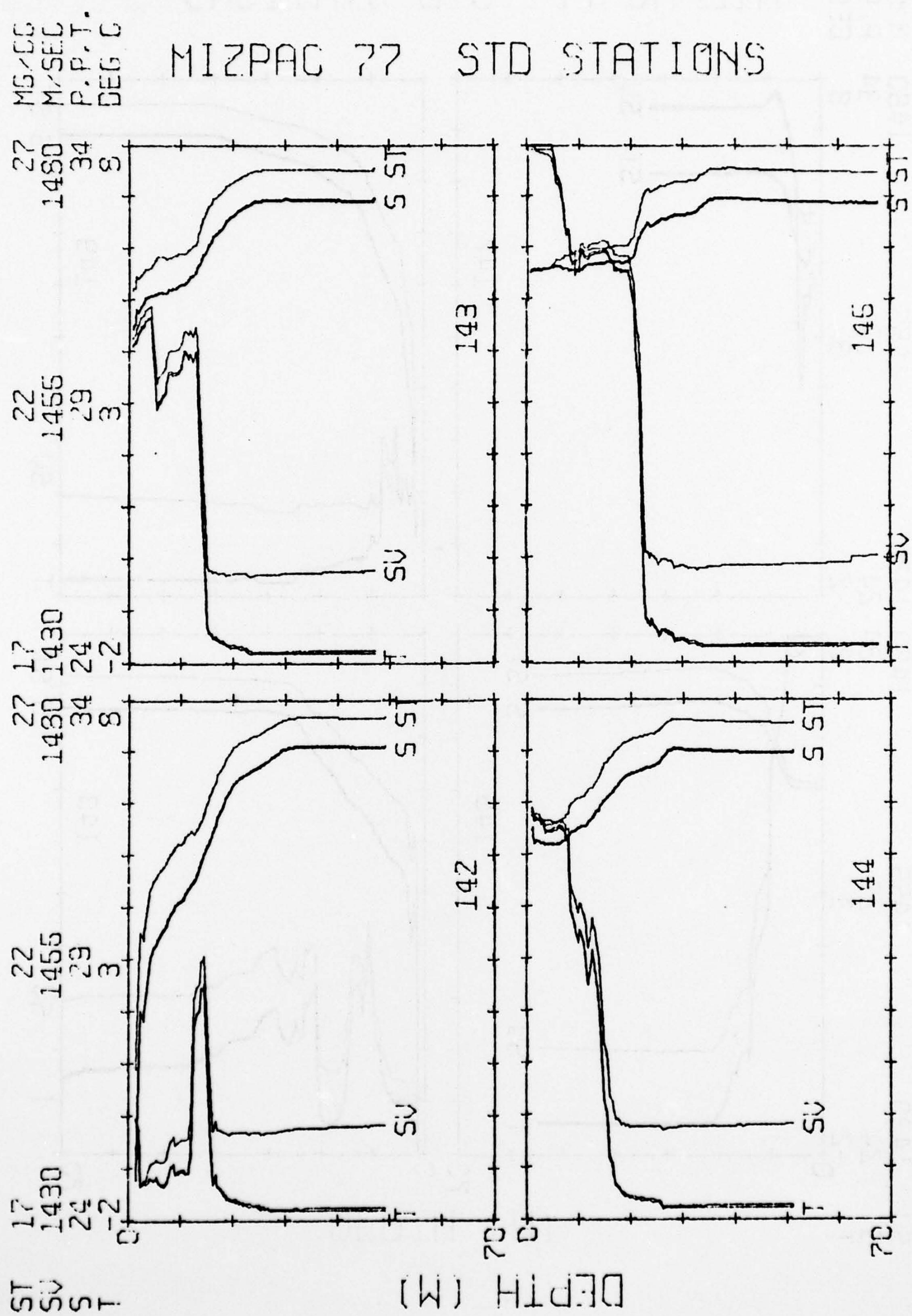
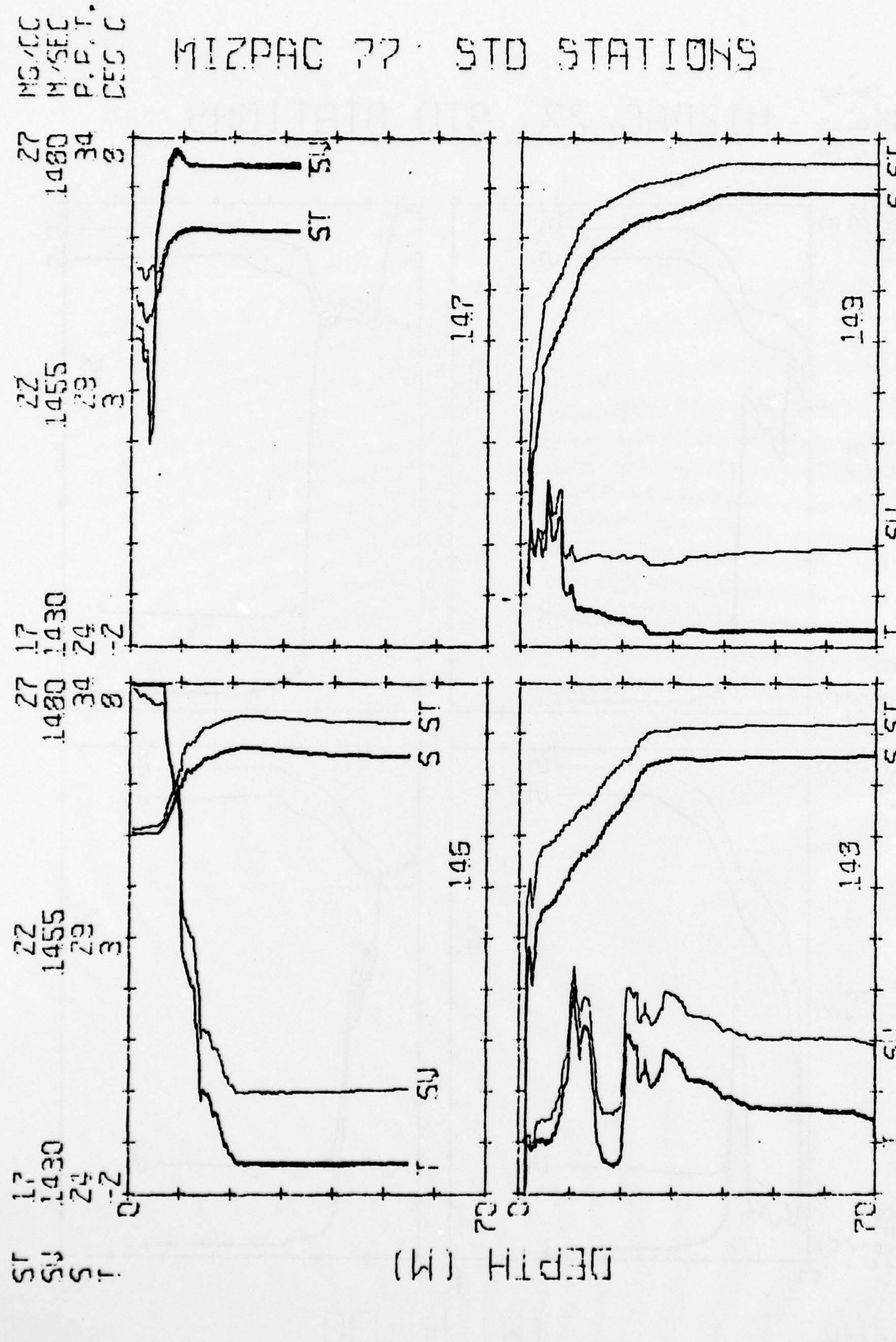
ST
SV
S
T
17
1430
24
-2
22
1455
29
3
27
1480
34
8
MG/CC
M/SEC
P.P.T.
DEG C
DEPTH (M)
0
70
T
SV
S
ST
134
135
136
137



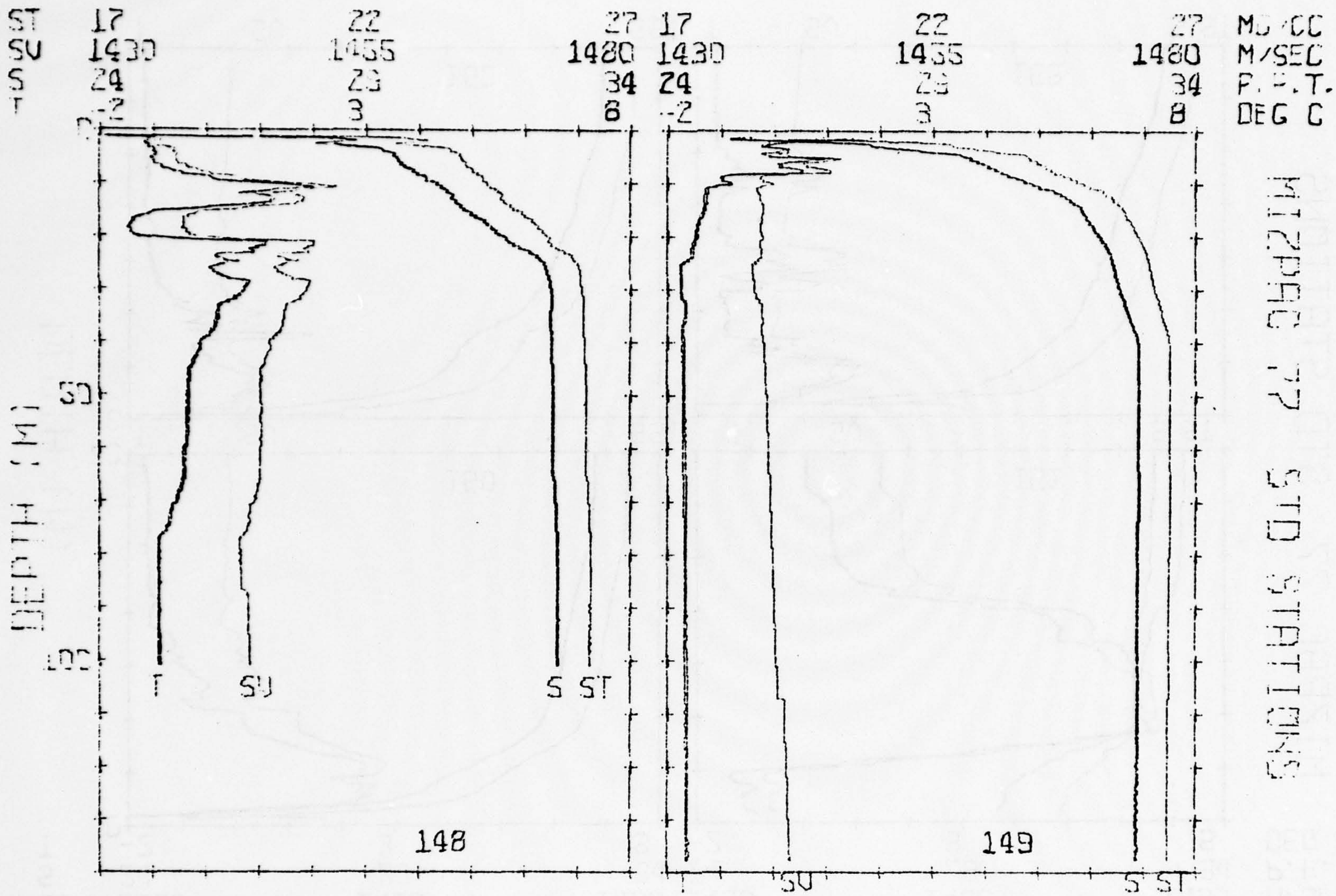
MIZPAC 77 STD STATIONS
DEPTH (M)

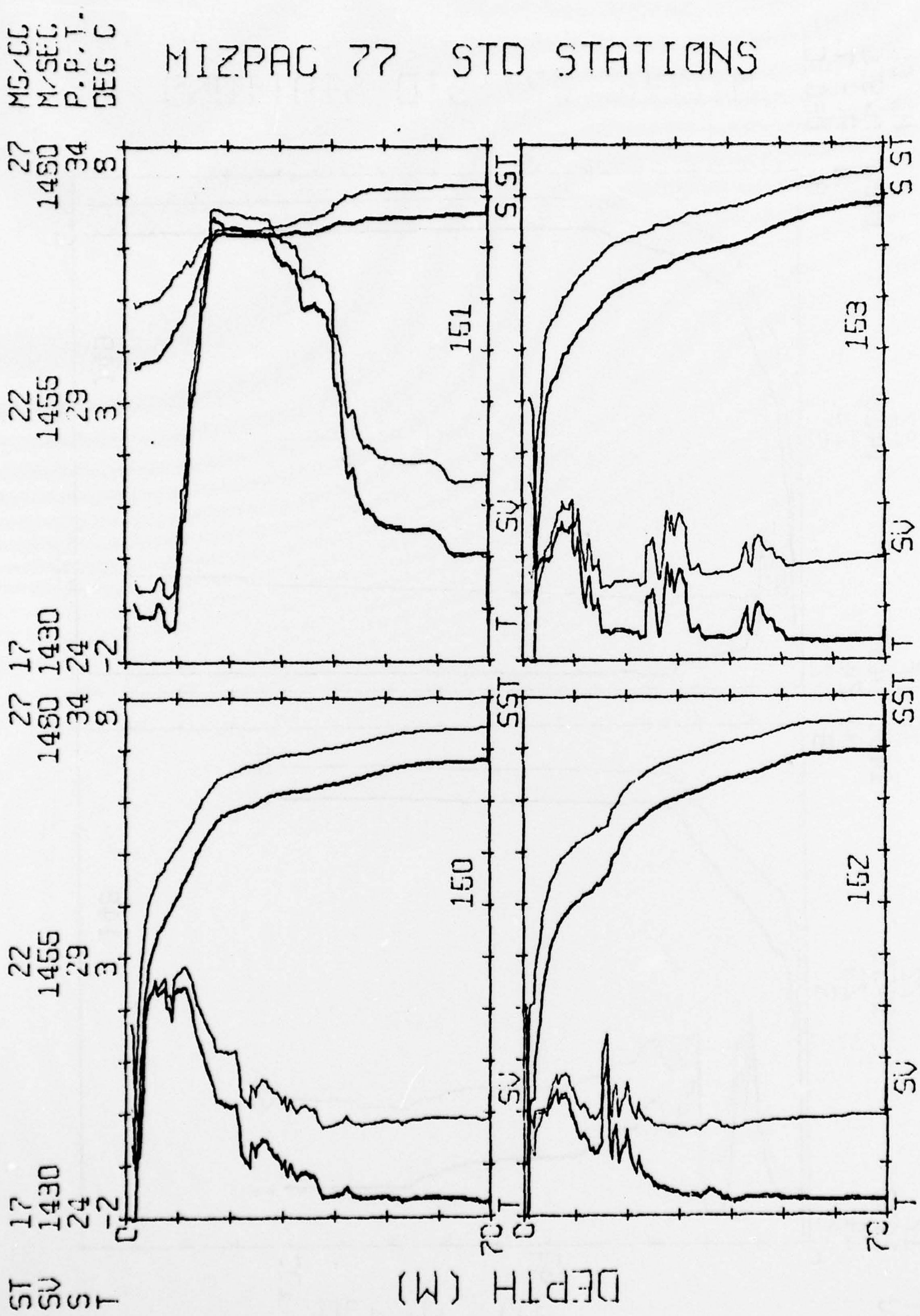


MIZPAC 77 STD STATIONS
MG/CC
M/SEC
P.P.T.
DEG C
143
145
142
144
S ST
S
SV
T
DEPTH (M)
0
70



MIZPAC 77 STD STATIONS
MG/CC
M/SEC
P.P.T.
DEG C
27
1480
34
8
22
1455
29
3
17
1430
24
-2
147
149
145
149
ST
SV
S
T
0
70
DEPTH (M)


MIZPAC 77 STD STATIONS
ST 17 22 27
SU 1430 1455 1480
S 24 29 34
T -2 3 8
MG/CC
M/SEC
P.P.T.
DEG C
DEPTH (M)
0
50
100
T
SU
S
ST
148
149



MIZPAC 77 STD STATIONS
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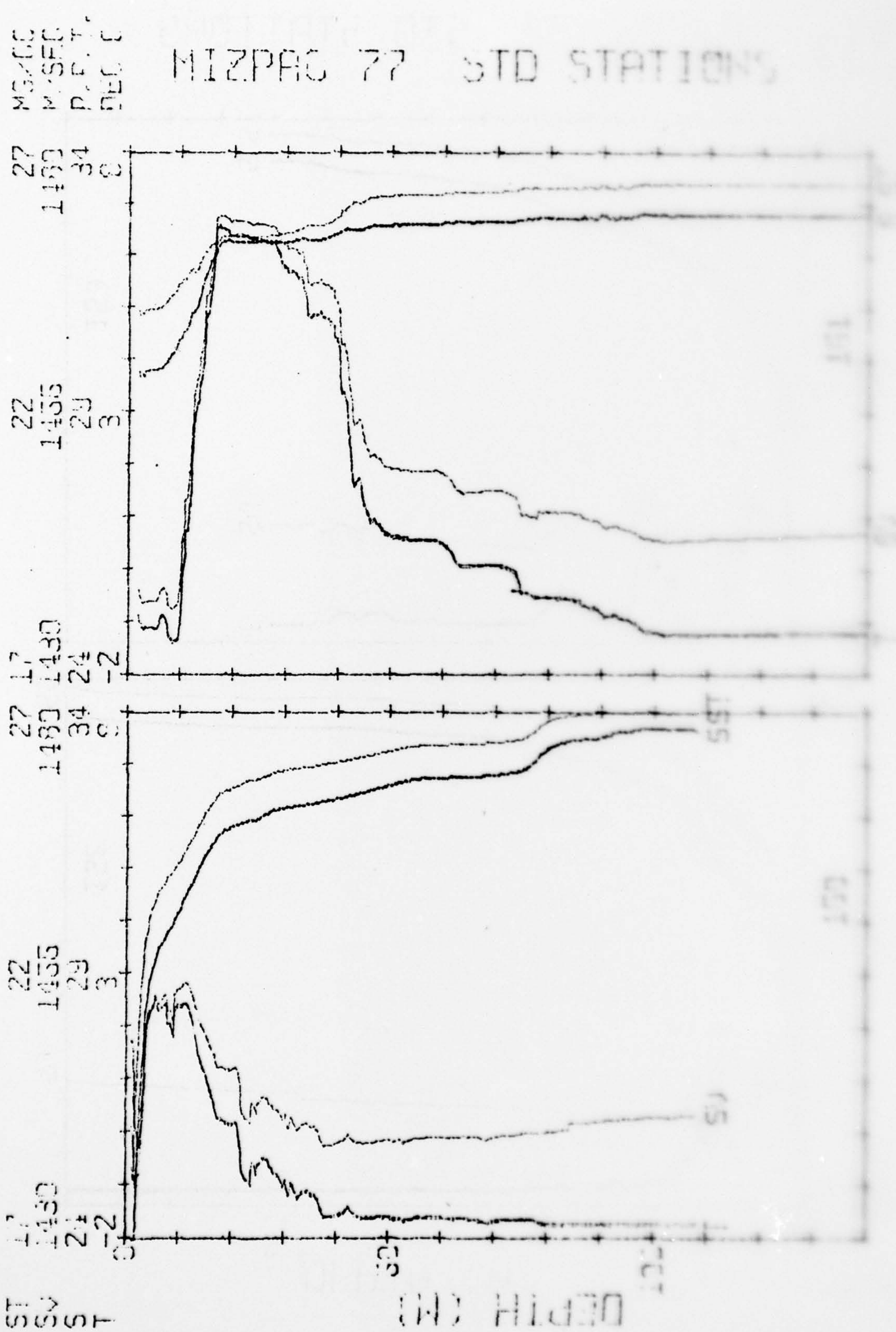
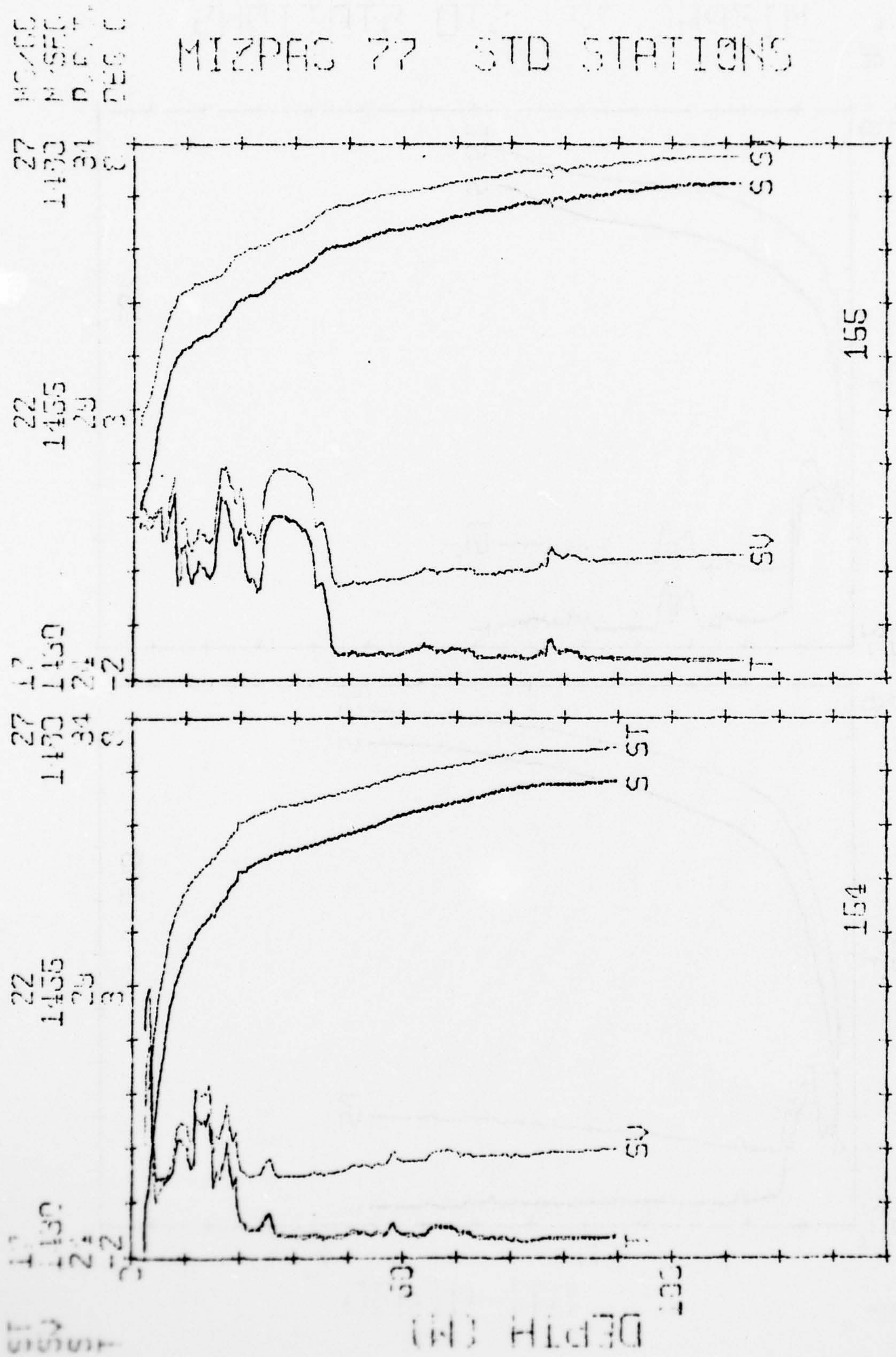
1450 M/SEC
34 P.P.T.
8 DEG C
22
1455
29
3
17
1430
24
-2
ST
SV
S
T
DEPTH (M)
0
70
150
151
152
153
S ST
SST
SV
T



MIZPAC 77 STD STATIONS
DEPTH (M)

MIZPAC 77 STD STATIONS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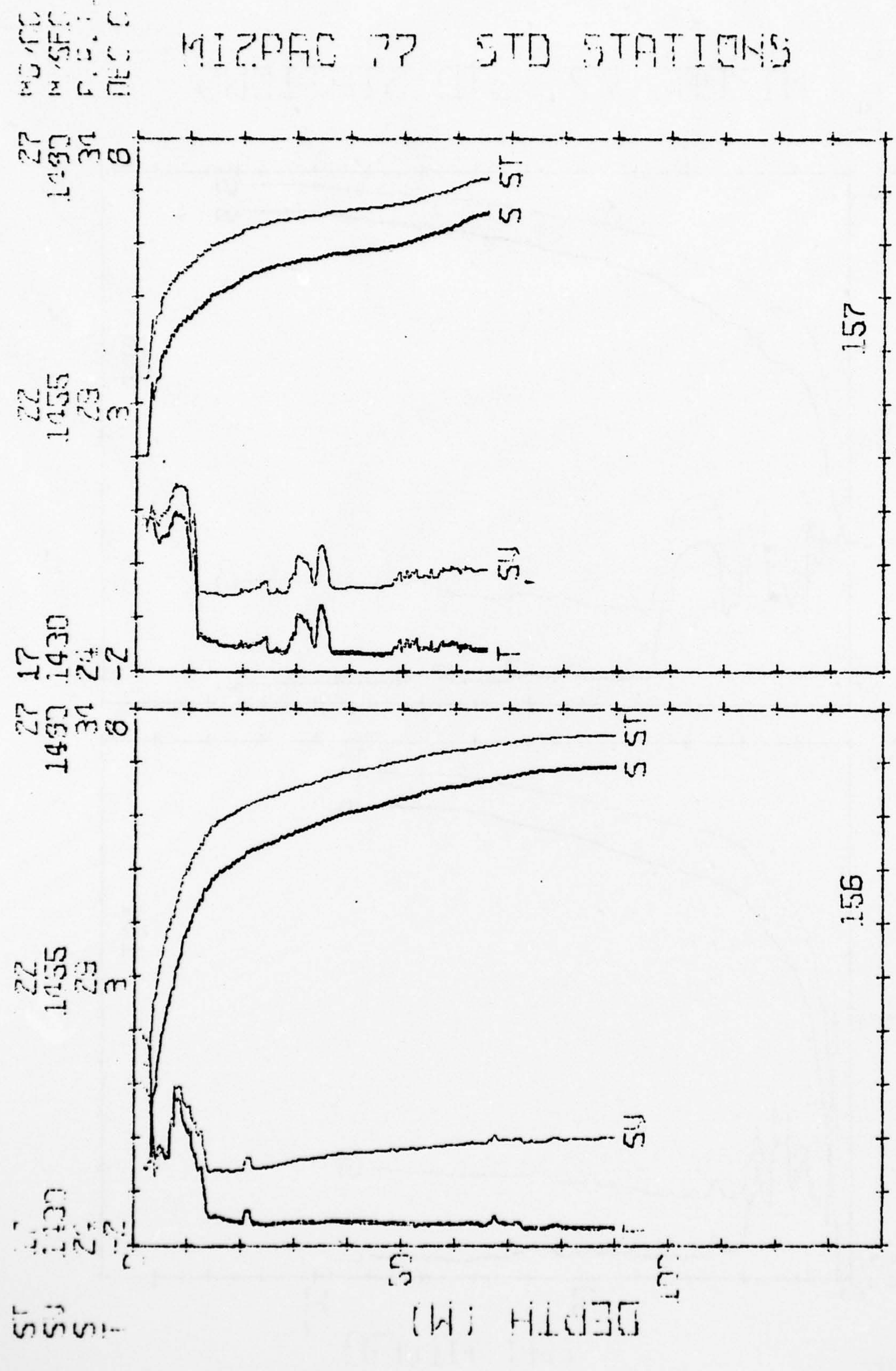
155
154


MIZPAC 77 STD STATIONS
S ST
S
SV
T
157
156
0
50
100
DEPTH (M)

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